INDIAN AGRICULTURAL
RESEARCH INSTITUTE, NEW DELHI.

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(Published May 30th, 1939)

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(Published August 28th, 1939)

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(Published Nevember 30th, 1939)

ON THE GROWTH OF THE EMBRYONIC SHELL OF THE JAPANESE RIVER SNAIL, *VIVIPARUS JAPONICUS*

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(With 5 figures)

(Received November 28, 1938)

The embryonic life of *Viviparus* species is passed in the maternal, enlarged oviduct, until the embryo attains an adult-like form of considerable size, e. g. about 9 mm. in the case of *Viviparus japonicus*. Accordingly, it is difficult to measure the embryonic growth on account of the difficulty of the time determination. The method of measuring the relative growth may, therefore, be the most adequate for ascertaining in part the nature of the growth. Here, the question arises of the discovery of a further method of ascertaining to some extent the nature of the actual growth itself. This paper is intended as a contribution to the study of larval growth in molluscan shells, with special reference to *Viviparus*, by the method of the relative growth and by the supplementary method for detecting partial features of growth. Here I wish to express my sincere thanks to Prof. E. Nomura who kindly gave me valuable guidance during the course of this investigation.

MATERIAL AND METHOD

The maternal specimens were collected from an irrigation channel for paddy-fields at the village of Hirose-mura, near Sendai in October, 1935. From these 12 specimens, the larvae, each of which was covered by its respective capsule, were removed from the maternal uterus. In size the maternal shells were in each case roughly equal. The number of embryos and the size of the maternal bodies, as shown by the largest diameter of the operculum, are tabulated in Table 1.

Three dimensions, viz. the length (*L*) of the shell as the greatest distance from the apex to the margin of the shell-aperture, the height (*H*) of the shell when the shell-aperture was laid on a plane surface, and the greatest distance from the margin of the shell-aperture to the edge

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TABLE 1

No of brood	Total no. of embryos in brood	No. of embryos examined	Largest diameter of operculum (mm.)
1	7	5	18.0
2	16	12	18.6
3	12	8	18.5
4	14	12	19.1
5	5	4	18.9
6	16	10	20.0
7	13	8	17.4
8	14	8	18.1
9	19	12	18.3
10	8	6	18 – 19
11	14	9	18 – 19
12	11	11	18 – 19
Sum	149	105	
Mean	12.4 ± 2.6		18.54 ± 0.47
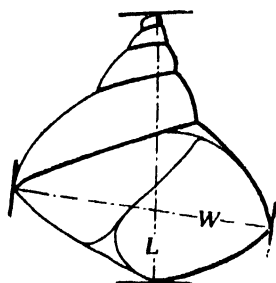
Fig. 1. Diagram showing the points in regard to which measurements were made.
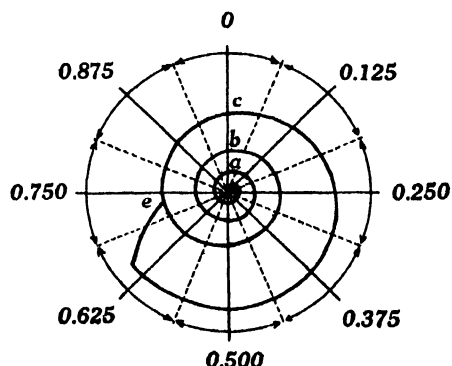
Fig. 2. Diagram showing the method of measuring the number of whorls. Explanation in text.

of the lowest whorl (W), were measured with a pair of callipers. The small specimens were not measured to avoid the incorrectness which occurs by depressing the soft shell which is not calcified enough. The earlier stages of development were, therefore, not investigated. They must be analysed by a more effective method of measurement.

In order to determine the grade of development and growth, the number of the whorls was calculated. Each shell was placed on a round paper sectioned into eight octants, which have a common vertex. The shell-axis having been placed on the origin, i. e. the centre of the sections, the tangential direction to the beginning of the first whorl at the shell-axis was allowed to coincide with the zero-line indicated in the present paper. Thus, the calculation of the number of whorls was made by that of the turns from the beginning point to the end (e in Fig. 2), up to

TABLE 2

No. of embryos examined	No. of whorls	Dimensions in cm.		
		L	W	H
2	2.375	0.225	0.185	0.145
1	2.500	0.320	0.270	0.170 +
1	2.625	0.340	0.300	0.200
3	2.750	0.363	0.313	0.237
2	2.875	0.365	0.315	0.225
2	3.000	0.365	0.315	0.220
2	3.125	0.365	0.330	0.275
5	3.250	0.478	0.422	0.298
1	3.375	0.450	0.380	0.270
6	3.500	0.485	0.435	0.287
9	3.625	0.546	0.489	0.333
9	3.750	0.623	0.568	0.383
9	3.875	0.643	0.586	0.397
17	4.000	0.735	0.675	0.443
12	4.125	0.781	0.705	0.468
5	4.250	0.810	0.724	0.486
3	4.375	0.830	0.757	0.500
6	4.500	0.878	0.808	0.535
1	4.625	0.960	0.900	0.590

one-eighth of a turn. For instance, in Fig. 2, the first whorl is measured at the point a, the second at the point b, the third at c, and at e, the total number calculated is 3.75 whorls. The measurements taken of every brood were adopted in the allometric equation, $\log y = \alpha \log x + \log b$, where x is the standard dimension, y the dimension comparable with x, α is the equilibrium constant, and b the local index*, of relative growth, especially where the dimension L is the standard. The total number of specimens was classified in relation to the number of whorls (Table 2).

RELATIVE GROWTH OF EACH BROOD AND THE LOCAL INDEX

The results of the calculation regarding the W/L and H/L relations of each brood are shown in Table 3. As seen in this table, α and $\log b$ in the allometric equation of the respective brood are different in value from each other, though these differences are slight. The differences between the greater and smaller values, however, seem to be statistically significant, even in the case of such a small number of observations; e. g. the differences in these constants between Nos. 4 and 6 in the W/L relation, and between Nos. 12 and 7 in the H/L relation are larger than 3·P. E. These differences are not only irregular, but it seems that, between

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* This term is explained in the following section.

them, there is a definite correlation; i. e. the value of $\log b$ decreases in parallel with the decrease in the value of α. Therefore, it may be assumed that the values of these constants in relation to each brood differ little by little from each other, respectively. From this tendency, it may be concluded that the general physiological conditions of the maternal body regulate the growth of its brood, even without taking into account any correlation between this growth and the number of the brood or the size of the maternal body.

The correlation between α and $\log b$ is given by the correlation-coefficients (r in Table 4). From these, it is evident that there exists an extremely close correlation. If a linear relation is, then, presumed between α and $\log b$, it may be expressed by the equation,

$$\log b = q - p\alpha$$

p and q being the constants. The actual values of p and q are given in Table 4 (Fig. 3). As seen in this table, the values of p are practically

TABLE 3

No. of brood	W/L relation		No. of brood	H/L relation	
	$\alpha \pm P.E.$	$\log b \pm P.E.$		$\alpha \pm P.E.$	$\log b \pm P.E.$
2	1.103 ± 0.025	1.97056 ± 0.00808	12	1.104 + 0.016	1.79186 ± 0.00374
3	1.093 + 0.024	1.97391 ± 0.00651	3	1.075 ± 0.046	1.78195 ± 0.01049
4	1.077 ± 0.020	1.97449 ± 0.00439	4	1.053 + 0.018	1.79419 ± 0.00396
1	1.068 ± 0.011	1.96839 ± 0.00313	8	1.029 + 0.061	1.79752 ± 0.01298
10	1.058 ± 0.022	1.96044 + 0.00458	2	0.965 + 0.021	1.78868 ± 0.00685
12	1.051 ± 0.021	1.96717 ± 0.00192	11	0.965 ± 0.038	1.77561 + 0.00706
7	1.044 ± 0.026	1.96132 ± 0.00894	10	0.950 ± 0.055	1.77032 ± 0.01168
5	1.035 ± 0.028	1.96515 ± 0.00798	7	0.929 + 0.018	1.76041 ± 0.00607
9	1.032 ± 0.048	1.96892 ± 0.00767	9	0.910 ± 0.016	1.76729 + 0.00734
8	1.002 ± 0.038	1.97393 ± 0.00821	1	0.886 ± 0.029	1.76818 ± 0.00790
6	0.966 ± 0.014	1.95135 ± 0.00436	5	0.870 ± 0.074	1.76292 ± 0.02121
11	0.956 ± 0.029	1.95458 ± 0.00542	6	0.802 ± 0.038	1.76829 ± 0.01146

TABLE 4

	W/L	H/L
r	0.702 ± 0.099	0.784 ± 0.075
p	0.115	- 0.113
q	0.154	- 0.332

equal in both relations. It has been already accounted for by LUMER (1936) that p and q are the common solution of the simultaneous equations, which consist of many allometric equations. That is, there exist the relations,

$$p = \log x_0, \quad \text{and} \quad q = \log y_0,$$

where x_0 and y_0 are the coordinates of the point, at which every allometric curve intersects. Therefore, the values of p and q vary with the unit, by which x and y were measured. b, the initial growth-index, so called by HUXLEY and TEISSIER (1936 a, b), also depends upon the measurable unit of x and y. In the present case, every dimension was measured by the unit of cm., which is larger than every dimension, so that the figures of b are, in every case, larger than every dimension. Consequently, the term,

"initial index," is very inadequate to the definition of the constant b. The term, "final index", might be more suitable for the present case. How the changes for these constants occur as the result of the change of unit, is shown in Fig. 3. At any rate, the use of the terms "initial" or "final index" must be given up for the general definition. In place of them, I propose the term, "local index", letting it have both meanings, i. e. that it provides a location of the equation, $\log y = \alpha \log x + \log b$, while α is its slope, and that, from this index, the "local constant" is derived in ecological significance (NoMURA, 1926, '28; HAMAI, 1934, '35, '38 b).

Fig. 3. log b/α relation The heavier lines represent the case in which the dimensions are measured by the cm.-unit, and the lighter by the mm.-unit. ○ W/L relation + H/L relation.

As has been pointed out by LUMER, p and q must be the coordinates on which every allometric equation intersects. But, in practice, every curve does not exactly intersect on p and q. This is a contradiction owing to the nature of the mere empirical approximation represented by the allometric equation and by this relation derived from it. Roughly speaking, every allometric equation, however, concentrates round p and q in the present case. This fact may tentatively suggest a certain biological significance.

DIMENSIONAL GROWTH IN RELATION TO
THE NUMBER OF WHORLS

The treatment of the growth in each brood in relation to the number of whorls is inadequate to the investigation of the growth on account of their small number. Now, the average dimensions, in all broods, classified by the number of whorls have been dealt with. By using these measurements the growth could be further analysed as the average results of growth.
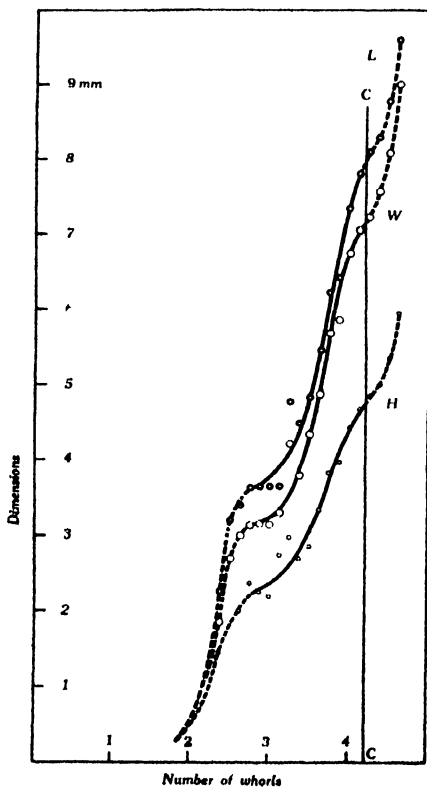
Fig. 4. Growth curves against the number of whorls. The full lines are the loci of the calculated values in the equations shown in the text. C–C line shows the critical point after which the embryo can hatch out.

When the dimensions, L, W, and H, have been plotted against the number of whorls (Fig. 4), three cycles of growth respectively have been clearly observed in each dimension. The cycles of respective dimension are coincident in point of the period (the number of whorls); i. e. the first cycle is over at about 2.8 in the number of whorls, the second continues from about 2.8 to 4.1–4.2, and the third commences with 4.1–4.2, invariably in every dimension. Every cycle has a sort of sigmoid character. In the second cycle, the following equations* seem to express suitably the observed values (Fig. 4).

$$\log \frac{L-3.55}{5.10-(L-3.55)} = 1.85(n-3.75)$$

$$\log \frac{W-3.10}{4.35-(W-3.10)} = 2.22(n-3.68)$$

$$\log \frac{H-2.20}{3.00-(H-2.20)} = 1.68(n-3.73)$$

where n indicates the number of whorls. According to the above facts, a parallel relation between the time and the number of whorls may be presumed. The number of whorls, then, may possibly be taken as a parameter of the time.

* The measurable unit for the dimension is mm.

IMAI (1937) has proved that under controlled temperature conditions the growth of the larval shell is twofold in the pond snail, *Lymnaea japonica*. According to him, the first cycle comes to a state of rest at the stage of metamorphosis from veliger to adult-like form, and the second represents the growth during the stage of adult-like form. In the case of *Viviparus japonicus*, individuals in the first cycle had such relatively small shells that not one of them could retract its body into the shell. This stage may correspond to the first cycle of *Lymnaea*. The second cycle of *Viviparus* indicates the growth during the stage of the adult-like form, as in the case of *Lymnaea*. In the latter, the hatching occurs at the end of 'the second cycle. But in the case of *Viviparus*, the further cycle appears with only an indication of its beginning. The larvae during this growth cycle showed active creeping movements when they were removed from the capsule, in which the albuminous fluid had, almost all, been already consumed. There may, therefore, be no objection to considering that they are hatched and are given birth from the maternal body, as soon as they complete the second cycle and enter the third. The last cycle may be a waiting period for birth.

Here, an interesting fact has been observed, viz. that the antilogarithms of p and q already mentioned in the previous section coincide, approximately, with the dimensions at the end of the second cycle (Table 5).

TABLE 5

Number of whorls	L		W		H	
	$\log^{-1}p$	At end of second cycle	$\log^{-1}q$	At end of second cycle	$\log^{-1}q$	At end of second cycle
4.1–4.2	7.7	8.0	7.0	7.2	4.7	4.8

From this fact, may easily be drawn the conclusion that the larval size when they are given birth to is fairly limited, in spite of any variation of the growth-conditions in the maternal bodies; i. e. the larvae in every brood always arrive at a relatively constant size up to the period of potential. But attention must be given to the fact that the above arguments all refer to the relative size. They are enough realized even though absolute variations of size in smaller and larger sized specimens are the same. LUDWIG (1937) has studied the relationship between the size and the velocity of heart-beat and of locomotion. The unification of size at birth may also suggest an energy-relation in the process of development. This problem

is very interesting, but will be left in future investigations.

AVERAGE RELATIVE GROWTH

The relative growth functions derived from the sigmoid growth curves have been studied by LUMER (1937) and by HAMAI (1937), and that the allometric equation is a special case or an approximation has also been confirmed. In the present case too, an exact fitness of the allometric equation is not to be expected, for the growth of all dimensions follows ROBERTSON's equation. The allometric equation makes what is merely an approximation. The application of the allometric equation, however, is not inconsistent, as in the case of many other biological laws, when taken as the first approximation (Fig. 5 and Table 6).

BRODY, DAVIS and RAGSDALE (1937) doubt, from the results of their investigation of dairy cattle and other animals, the significance of deriving allometric equations from time equations, because the equation is only adapted to the data of animals of mixed ages, and because time does not

Fig. 5. Log/log plot of W and H against L. The straight lines represent the allometric curves. The dotted lines are the loci derived from the ROBERTSON's equations,

$$\frac{W-3.10}{4.35-(W-3.10)} = 1.43 \left\{ \frac{L-3.55}{5.10-(L-3.55)} \right\}^{1.20}$$

and $\frac{H-2.20}{3.00-(H-2.20)} = 1.08 \left\{ \frac{L-3.55}{5.10-(L-3.55)} \right\}^{0.91}$

TABLE 6

Relation	$\alpha \pm$ P. E.	$\log b \pm$ P. E.
W/L	1.065 ± 0.0030	1.90324 ± 0.00241
H/L	0.941 ± 0.0075	1.83296 ± 0.00598

enter into the adaptation of the equation to the data. This doubt may have arisen on account of there being no consideration taken of the variation in the size of specimens of the same age and of the variations occurring indiscriminately in specimens of two or more different ages. HAMAI (1937, '38 a) has noticed a relationship between growth and variability, and has further pointed out that both growth and variability can be expressed by the equation, $y = bx^\alpha$, but they should be separated when taking the time factor into account (1938 b). Thus, the derivation of the allometric equation from the time relations are significant biologically. In the case in which the time factor, e. g. the time of inflection in ROBERTSON's equation, is approximately equal in the two, as in the present case, the allometric equation is more practically useful than that derived from the time equations, although, if the time factor is largely different between them, as in the case of some limpets (HAMAI, 1937), the latter has a greater applicability and significance than the former.

NOMURA (1926) has shown the value of α as 1.00 for the H/L relation of *Viviparus japonicus var. iwakawai*, but because of his definition of the dimension L which differs from that of the present case, comparison between the two values of α is impossible. In the larval growth of *Semisulcospira libertina*, $\alpha = 0.73$ as regards the W/L relation has been found by OHUYE (1934). In this case too, the measurable direction is not exactly similar to my case, but the great difference between both values of α is very notable. That is, *Viviparus* shows a slight positive allometry, and, on the contrary, *Semisulcospira* a remarkably negative one. In other words, *Viviparus* gradually acquires roundness, while *Semisulcospira* grows more and more elongated. These are the specific or genetic characteristics of growth and development.

SUMMARY

The growth of the embryonic shell in *Viviparus japonicus* has been analysed by means of the data of four measurements, three dimensions and the number of whorls, and then summarized as follows: —

1) Little by little the relative growth of each brood is continuously different from that of the others.

2) The constants b and α in the allometric equation applied to each brood have approximately the definite relation, $\log b = q - p\alpha$, p and q being the constants.

3) There exist three cycles of growth; the first cycle is represented

by the growth before the stage of the adult-like form, the second is that of adult-like form stage, and the third, which is the beginning only, is the stage having possibility of birth.

4) The antilogarithms of p and q coincide approximately with the size at the end of the second growth-cycle.

5) The average relative growth is expressed by $W = 0.8003\ L^{1.008}$ and $H = 0.6807\ L^{0.941}$, where W, H, and L are the dimensions measured by the unit of cm.

6) The terminology of b in the allometric equation has been examined, and the term, "local index," has been proposed for b.

7) The significance of derivation of the relative growth function from time equations has been discussed.

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BODY TEMPERATURE OF THE STRAWBERRY WEEVIL, *ANTHONOMUS BISIGNIFER* SCHENKLING, AND ITS LIMITING FACTORS

(THE DIURNAL RHYTHM OF ACTIVITIES IN INSECTS AND ITS ENVIRONMENTAL CONDITIONS, NO. VI.)*

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(With 6 figures)

(Received December 12, 1938)

INTRODUCTION

It is well known that diurnal rhythm is distinctly noticeable in the case of insect activity. It is generally understood that this periodicity found in insect activity depends upon the diurnal rhythm of the environmental conditions, mainly upon any of the meteorological factors. It is, therefore, natural that in the case of the ecological investigations made on insect activity, the problems concerning some meteorological factors correlating the said activity have generally been dealt with.

Now, the periodicity of insect activity is generally divided into three types, i. e. the diurnal activity, the nocturnal activity and the diurnal-nocturnal activity (PARK, LOCKETT & MYER, 1931).

In my previous papers it was clearly shown that the Strawberry Weevil

is one of the diurnal insects (KATÔ, 1937ₐ, 1938ₕ), and thus a close correlation between its egg-laying activity and the solar radiant energy was statistically recognized (KATÔ, 1937 ₐ, ₕ). It was also observed that some weevils, which had been in a resting state during the night, became suddenly active soon after sunrise, being influenced by the increase of the solar radiant energy, and this fact was especially clear in those exposed to the sunshine. It was also noticed that the locomotion velocity was markedly diminished when affected by the decrease of solar radiant energy, caused by passing clouds obscuring the sun (KATÔ, 1938ₕ). Furthermore, it was distinctly observed both in the field and in the experiment that the weevils were equally active in the dark and in the light when it was warm (KATÔ, 1938ₕ). It may consequently be concluded that the diurnal rhythm occurring in the activity of the Strawberry Weevil is governed by various environmental temperature factors, such as solar radiant energy, air temperature and the soil surface temperature. It may moreover be concluded that we must, in the field ecology, pay attention to solar radiant energy as one of the important temperature factors (KATÔ, 1938ₕ). Accordingly it may be important to concentrate our attention on the ecological investigation of the body temperature of the insect, since the environmental temperature factors do not directly affect the insect activity, but only indirectly through the body temperature (KATÔ, 1937ₐ). Therefore, in the ecological investigation of the diurnal activity of the Strawberry Weevil, the qualitative observation of the activity and the microclimatic measurement of the external temperature factors must be connected with a simultaneous recording of the body temperature.

The investigation of the body temperature of a locust, *Schistocerca gregaria* FORSK, executed by BODENHEIMER is very noticeable. In this case, the body temperature was lower than the air temperature before sunrise, but it became suddenly higher when the sun began to shine, and fluctuated during the daytime showing a temperature lying between 40 and 45°C, which was, of course, higher than the air temperature but lower than that shown by the black bulb thermometer (BODENHEIMER, 1930). Recently HUSSEIN published an elaborate work concerning the temperature limits of the various stages of activity using several kinds of grass-hoppers as material (HUSSEIN, 1937). In the preface of this paper, UVAROV has given several interesting and noticeable suggestions to the field ecology. He said that the various types of locust activities are governed by the body temperature, and that therefore the attention must be concentrated not on the air temperature, but on the body temperature of the insects

themselves, and that a better result will be obtained by studying the normal behavior of locusts with the aid of a black bulb thermometer, reading of which may change in parallel with the change of actual body temperature.

In the present paper I have dealt with the correlation existing between the body temperature of the Strawberry Weevil and solar radiant energy.

Before proceeding further, I wish to express my sincere thanks to Prof. Dr. SANJI HÔZAWA for his kind instruction and encouragement and to Assist. Prof. Dr. ISAO MOTOMURA for the valuable suggestions and criticisms which I received from him during the course of my investigation. I wish also at this time to take the opportunity to thank Prof. Dr. SAEMON-TAKO NAKAMURA, the director of the Mukaiyama Observatory of the Tôhoku Imperial University, and Assist. Prof. YOSIO KATÔ, my elder brother, who gave me much assistance in using the mirrow-galvanometer and who also made many suggestions during the present investigation. I am also grateful to all the members of the Mukaiyama Observatory for their kind consideration.

MATERIAL AND METHOD

The over-wintered weevils appear in the strawberry garden in the early spring and soon they begin to lay eggs inside of the flower-buds. The larvae hatched out from eggs thus laid will grow by eating the pollen-sac and receptacle and then will pupate. Then adult weevils emerge out of the injured buds and injure again to some extent the green leaves of the strawberry and then sooner or later hibernate. In the present experiment these newly emerged weevils were used.

The thermo-electric method was applied to measure the body temperature. The bodily dimensions of this weevil are very small; for instance, the elytron is only 1.985 mm. in the male and about 2.069 mm. in the female in the case of the specimens taken from Sendai (KATÔ, 1938,). Accordingly the thermopile must be specially designed to be suited to measure the body temperature of such small insects. Fortunately, I was able to obtain a very good one prepared by the factory belonging to the Tôhoku Imperial University and manufacturing scientific apparatus. It was made to measure the difference between the body temperature and the air temperature. The body temperature was represented by the temperature of the coelom into which the thermopile was inserted through the abdominal end. The solar radiant energy was measured by a solarimeter. The fluctuation of the body temperature and that of the solar radiant energy were recorded using mirror-galvanometers (moving-coil type ;

sensibility, 10^{-8} *amp.*; coil resistance, ca. *60 Ω*; free period, ca. *2 sec.*). The experiments were executed on the outdoor lawn and indoor dark room of the Mukaiyama Observatory of the Tôhoku Imperial University.

RESULTS

It is a well known fact that the heat-taking in insects is done mainly by radiation and convection, while the heat-loss is executed mostly by evaporation (KOIDSUMI, 1935). In the case of a small insect such as the Strawberry Weevil, the body surface is rather large in relation to the body size. It may, accordingly, be easily recognized that the solar radiant energy will have a great effect upon the heat-taking, and that the heat-loss from the body will be remarkably affected by the air-condition which may have an influence upon the evaporation from the body of the insect.

In the following paragraphs I should like to mention the results obtained in the present investigation.

Experiment No. 1 (Fig. 1).
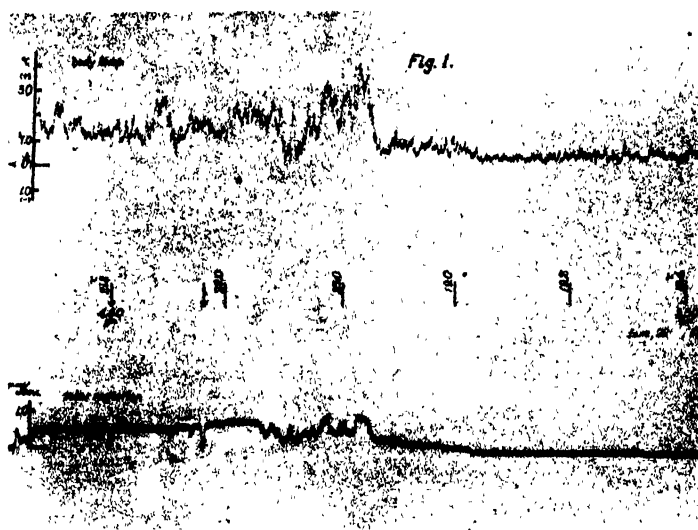
Breaking of circuit was indicated by arrow.

Time....................3.50 – 4.50 p.m., 22nd of June.
Air temperature ....19.0 – 23.0°C.
Cloud form...............*Strato-cumulus.*
Wind velocity..............ca. 3 m/sec.*

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* The records of wind-velocity were cited from those prepared by the Mukaiyama Observatory.

It was a cloudy day, the sky being covered by *Strato cumuli*, but as the western sky was fine, the sun began to shine from about 4.10 p. m. The body temperature was almost equal to the air temperature or was somewhat higher than the latter during the time when the cloud appeared, but it became about 2°C higher than the air temperature after the sunshine began.

Experiment No. II (Fig. 2).

Time .... 2.50 - 3.20 p.m., 23rd of June.
Air temperature .... 24.8 - 29.8°C.
Cloud form .... *Cirro-stratus*.
Wind velocity .... ca. 3.5 m/sec.

The body temperature was about 3°C higher than the air temperature until about 3 p.m., but it dropped to the same level as the air temperature being influenced by *Cirro-strati* which obscured the sun from about 3 p.m. to 3.10 p.m. But the body temperature rose again when the clouds became thin.
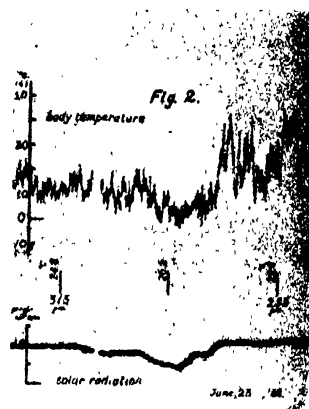
Experiment No. III (Fig. 3).
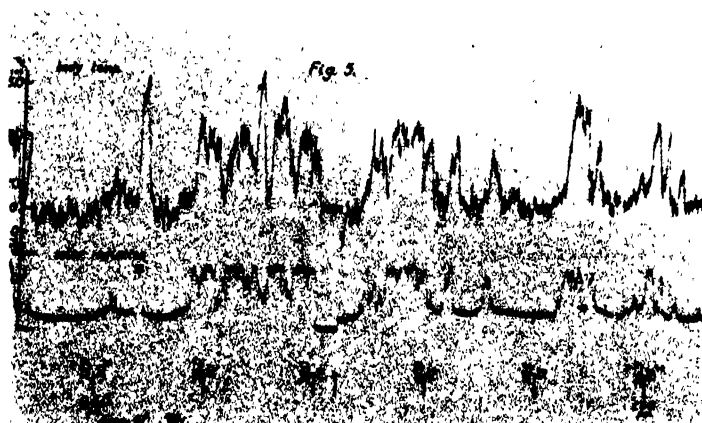
Time .... 0.30 - 1.40 p.m., 27th of June.
Air temperature .... 25.0 - 28.0°C.
Humidity .... 77 - 80 per cent.
Cloud form .... *Cumulus*.
Wind velocity .... ca. 3 m/sec.

It was fine from morning, but the solar radiation showed many fluctuations being affected by the coming and the going of clouds. The body temperature showed an interesting fluctuation, being influenced by the sunshine which was cut off very frequently by clouds. During the shining of the sun the body temperature was, on the whole, about 3°C higher than the air temperature, but when the sun was obscured by *Cumuli* it dropped to a degree similar to that of the air temperature.

Experiment No. IV (Fig. 4).

Fig. 4.
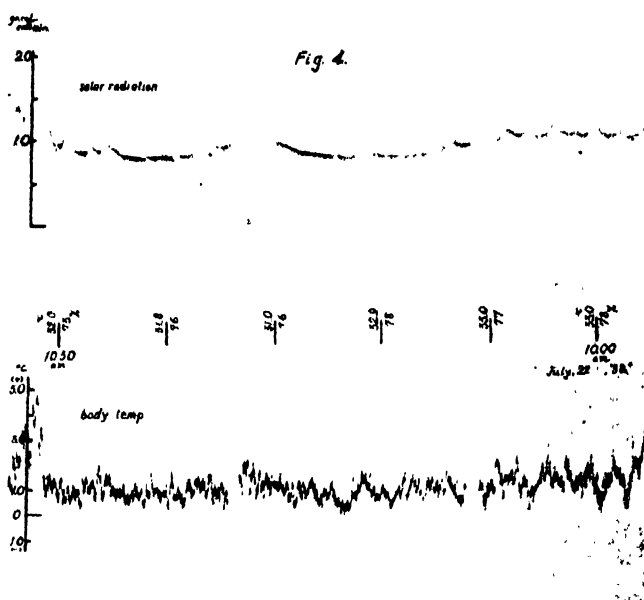
Time......................10.00 - 11.00 a.m., 22nd of July.
Air temperature ....31.0 - 33.0°C.
Humidity.................73 - 78 per cent.
Cloud form..............*Alto-cumulus.*
Wind velocity............ca. 1.5 m/sec.

On this day the sky was covered from early morning by *Alto-cumuli* and the sun shone often through breaks in the clouds. The solar radiation was fairly strong, as the clouds were thin. The body temperature fluctuated generally in parallel with the change of the solar radiation, showing a temperature about 1°C higher than that of the air. After 10.50 a.m. the body temperature rose suddenly, the clouds being blown away.

Experiment No. V (Fig. 5).

Time.............0.00 - 0.30 p.m., 26th
                     of June.
Air temperature....32.0 - 32.8°C.
Humidity..........62 - 64 per cent.
Wind velocity......ca. 10 m/sec.

On this day the sky was bright
and clear, but it was very windy and
dry. The body temperature was not
so high as was expected even when
it was exposed to strong solar radia-
tion, being only 2°C or 3°C higher
than the air temperature. This may
be easily understood from the fol-
lowing fact, i. e. the evaporation from
the body was accelerated by the dry air blown over it. This may be
made clearer by the fact that the falling of the body temperature was
very remarkable, becoming about 1°C lower than the air temperature,
when the sunshine was artificially cut off.

Experiment No. VI (Fig. 6).

Time ....10.20 - 11.00 a.m., 20th
                     of July.
Air temperature ..29.4 - 30.6°C.
Humidity ....81 - 82 per cent.
Wind velocity ....ca. 1 m/sec.

It was a fine day, and thus a
strong solar radiation was measured.
The body temperature was measured in shadow where no solar radiation
was observed, and thus it was almost equal to the air temperature.

The experimental results thus far obtained are mentioned in the fol-
lowing table.
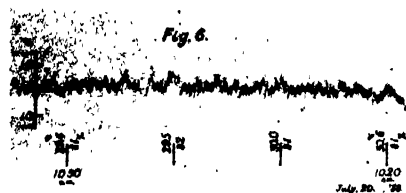
Exp. No.	Air temp. (°C)	Humidity (%)	Wind velocity (m/sec.)	Cloud form	Solar rad. (gr. cal./cm². min.)	Difference Body temp. and Air temp. (°C)
I	19.0–23.0	—	ca. 3	*Strato-cumulus*	0.2–0.7	0.0 –2.0
II	24.8–29.8	—	ca. 3.5	*Cirro-stratus*	0.4–1.2	0.0–3.0
III	25.0–28.0	77–80	ca. 3	*Cumulus*	0.3–1.3	0.0–3.0
IV	31.0–33.0	73–78	ca. 1.5	*Alto-cumulus*	0.8	1.0–1.5
V	32.0–32.8	62–64	ca. 10	—	1.4	2.0

DISCUSSION

(I) In the normal field condition the body temperature of the Straw-berry Weevil rises being influenced by the increase of solar radiation and it falls with the decrease of the latter. That is to say, the body temperature fluctuates in parallel with the change of the solar radiation. The other environmental factors, such as the relative humidity and the wind, seem to have almost no effect upon the general process of the fluctuation of the body temperature.

(II) It is very interesting to learn that the fluctuation process of the body temperature is only influenced by the solar radiation and this primary fluctuation is complicated by a secondary fluctuation which may be induced by other environmental factors. That is to say, the body temperature fluctuates always momentarily along with the general process of the primary change ; and consequently the evaporation from the body seems not to be uniform. It may be easily recognized from the above fact that the environmental condition is not always altogether quiet, but the air is always moving slightly. The secondary fluctuation above mentioned is, therefore, remarkable when the wind blows strongly (Fig. 5) and thus it may have a close correlation with the waves of the wind.

It seems that this secondary fluctuation is not due to the physiological condition of the Strawberry Weevil, as the body temperature was kept almost constant when it was measured within a small box where the air was prevented from moving.

(III) In the case of the strong wind and of the dry air, the body temperature of the Strawberry weevil is not on the whole so high as might be expected, though the solar radiation is strong enough. This may be due to the fact that the relative amount of the heat-taking is diminish-ed, being influenced by the remarkable heat-loss which was accelerated by the strong evaporation.

(IV) Now, it may be permissible to conclude that in the case of the Strawberry Weevil the body temperature, which originates from the air temperature, generally fluctuates being influenced by the change of the solar radiation ; and thus other environmental factors, such as the humidity and the wind, seem to have almost no effect upon the general process of changing the body temperature and consequently are to be treated ·as secondary factors.

(V) It was noticed from the data obtained in the present investigation that the body temperature of the Strawberry Weevil comes to be in

harmony with the environmental condition in the lapse of 15 or 20 seconds after sunshine, and in a similar time of duration or slightly longer of the same after the sun is obscured by clouds. If we take into consideration the large body surface in relation to the size of the body in the case of the Strawberry Weevil, it is possible that the time necessary for the heat-taking or for the heat-loss may be shorter when compared with those shown by other investigations (BODENHEIMER, 1930).

SUMMARY

In the present paper the results obtained in the investigation concerning the correlation which exists between the body temperature of the Strawberry Weevil and the solar radiant energy are mentioned. The process of fluctuation of the body temperature in the case of the Strawberry Weevil is caused primarily by the increase and the decrease of the solar radiant energy; and the momentary fluctuation which is to be added secondarily to the primary fluctuation is induced by the other environmental factors, mainly by the moving of the air.

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NOTE ON THE PRESENCE OF GANGLION CELLS IN THE HEART OF *PORCELLIO SCABER* LATREILLE

By

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(With 1 figure)
Received December 14, 1938

A great number of articles have already been written on the innervation of the crustacean heart. Both the existence of cardiac nerves and the presence of ganglion cells in the wall of the crustacean heart have been confirmed histologically as well as physiologically by many investigations, such as those by DOGIEL (1894) on *Astacus*, by NUSBAUM (1899) on *Squilla*, by NEWMYWAKA (1928) on *Potamobius*, and by ALEXANDROWICZ (1913, '32) on *Palinurus* and *Carcinus*. But these works have treated mainly the heart of the Decapods.

Of the Isopods, ROSENSTADT (1889) has studied the organisation of *Asellus*; McMURRICH (1897) the epithelium of the midgut of three terrestrial forms of the same group; SCHONICHEN (1899) the intestine of *Oniscus, Porcellio, Aramadillidium,* and of *Asellus*; REHORST (1914) the stomach of *Asellus*, and WALKER (1935) has observed the central nervous system of *Oniscus*. Thus there have been written many papers on the Isopods, but only a few of these deal with the innervation of the heart.

The present author has previously published two papers, reporting the presence of nerve cells in the hearts of two species of Isopods, *Ligia exotica* (1934) and *Tylos granulatus* (1935). The present investigation is a continuation of the above mentioned investigations, and deals with the innervation of the heart of *Porcellio scaber* which belongs to the same group.

The material on which the present investigation is based was collected in the garden of the Biological Institute. Since the methods adopted in the present investigation are almost the same as those shown in my previous works, I shall not allude to them here.

The innervation of the six nerve branches which arise from the abdominal ganglion situated most posteriorly of the nerve-chain, is almost similar to that seen in the case of *Ligia exotica*. The nerve-chain of this

animal runs along the ventral median line of the body. The anterior four pairs of nerve branches of six above mentioned run laterally and the remaining two pairs of the same innervate the posterior parts of the body running along the digestive canal.

The tubular heart runs straightly along the dorsal median line of the body arising from the fourth thoracic segment and terminates blindly in the fourth abdominal segment.

Along the median line of the heart, a nerve fibre bundle runs straightly and posteriorly, being attached to the inner surface of the dorsal wall.

The minute nerves of the heart, as well as their connection with the abdominal ganglion, could not be traced exactly. But judging from the close resemblance in the structures of the heart and in the features of the abdominal ganglion, it seems to me that the nerves found in the heart of this Isopod have originated from the abdominal ganglion as was seen in the case of *Ligia*.

The nerve fibre bundle of the heart contains six ganglion cells, and these are arranged longitudinally along the heart. The first ganglion cell which is situated most anteriorly is seen about in the fifth thoracic segment and the second one is in the sixth. Both the third and the fourth ganglion cells are situated at the seventh thoracic segment and are placed quite close to each other, but they never come into contact as in the case of the pill-bug. The remaining two ganglion cells are found in the first and second abdominal segments respectively.
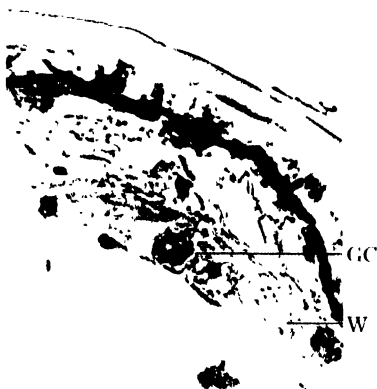
Fig. 1. Photograph of a ganglion cell in the heart of *Porcellio scaber*. ×400. GC. ganglion cell; W. heart wall.

All of the ganglion cells above alluded to are multipolar in shape and are almost the same in size as the nerve cells found in the abdominal ganglion. Each of the ganglion cells measures about 22 μ in length and 15 μ in width and bears a clear round nucleus with a diameter of 9 μ. In the center of the nucleus, one clear nucleolus was found in each case (Fig. 1). It was not possible to determine the minute innervation of the heart as the size of the heart is too small for this purpose.

In comparing the results obtained from the present investigation with those obtained from previous investigations,

Porcellio scaber seems to more closely resemble the pill-bug than *Ligia exotica* does, in regard to the size and arrangement of the ganglion cell.

SUMMARY

In the present report, the ganglion cells in the heart of *Porcellio scaber* were dealt with. This animal also has six ganglion cells in the heart as was found in the cases of two other Isopods, *Ligia exotica* and *Tylos granulatus*, and in size and arrangement they are very similar to those of the pill-bug.

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THE DEVELOPMENT OF THE PRIMARY MESODERM IN SPHAERIUM JAPONICUM BIWAENSE MORI

By

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(With Plates I-II and 19 Text-figures)

(Received December 22, 1938)

The mesoderm of Lamellibranchia is formed by the primary mesoderm and the larval mesoblasts.

In many species, the primary mesoderm appears first as the second somatoblast (4d). This somatoblast is a descendant of the posterior endoblast and the largest cell in the fourth quartet of cleavage. In the blastula stage, the second somatoblast divides bilaterally into two equal parts. Each daughter cell of this division sinks into the postero-ventral portion of the blastocoel, and becomes the so-called " mesodermal teloblast." Each mesodermal teloblast gives rise to each half of the primary mesoderm in the blastocoel, which is posterior to the primitive gut. The primary mesoderm then grows by its own multiplication and develops into mesodermal organs of various kinds throughout the gastrula and larval stages. The primary mesoderm of Lamellibranchia is assumed to be correspondent to the mesodermal bands of Annelida and of Gastropoda. In almost every species of Lamellibranchia, however, this primary mesoderm, in the early development, is indicated by a pair of masses of the teloblastic cells instead of a pair of bands. ZIEGLER (1885) seems to be one of the first investigators of the developmental changes of such teloblastic cells, although his description of *Cyclas cornea* (=*Sphaerium corneum*) is somewhat rough. Only two detailed investigations of the development of the primary mesoderm in Lamellibranchia have been offered by HERBERS (1914) and by FERNANDO (1931) in regard to their respective species, *Anodonta cellensis* and *Ostrea edulis*.

On the other hand, another view concerning the primary mesoderm has been held, which conflicts with the result of the above-mentioned investigations. MEISENHEIMER (1901 a, b) has stated, regarding *Dreissensia polymorpha* and *Cyclas cornea*, that the primary mesoderm is enlarged by the addition of the ectodermal cells, which are multiplied by prolifer-

ations from the posterior body wall. HARMS (1908) also supported the same view as MEISENHEIMER's in his study of Unionidae.

In *Sphaerium japonicum*, the paired teloblastic cell-masses of the mesoderm are seen in the gastrula stage, and the future heart, the pericardium, the kidneys and the germ cells are formed at the position of the primary mesoderm, as stated already in my previous papers (OKADA, 1935, '36, '38). Thus, the problem which has drawn the present writer's attention is a complete investigation of the proper connexion between the primary mesoderm and those organs. In the present paper, the writer will give a detailed account of the developmental features of the primary mesoderm of *Sphaerium japonicum*, with special reference to the formation of the protonephridia, the primordial germ cells, the kidneys, and the heart and pericardium.

The writer wishes very gratefully to acknowledge the kind guidance of Prof. Dr. E. NOMURA during this investigation.

MATERIAL AND METHOD

The material used in the present study was identified as *Sphaerium japonicum biwaense* MORI, a freshwater bivalve. Besides the earlier specimens used in the previous studies, fresh ones were collected in September of 1937, from a drainage ditch at Ipponsugi on the eastern vicinity of Sendai.

They were in most cases fixed in Zenker's solution without glacial acetic acid and stained by Mallory's connective tissue staining method. Besides this fixation, a few others, such as Allen-Bouin's solution or a modification of Champy's solution and staining methods with boraxcarmine with haematoxylin or with fuchsin and methyl green after Auerbach were tried supplementally. The sections were made serially, $7\,\mu$ or $10\,\mu$ in thickness by the paraffin method, and $30\,\mu$ in thickness by the celloidin method.

RESULTS OF OBSERVATION

THE FORMATION OF THE TELOBLASTIC CELL-MASSES OF THE MESODERM DURING THE BLASTULA AND GASTRULA STAGES. .

As already stated in the previous paper (OKADA, 1935), two macromeres, the first and second somatoblasts, designated 2d and 4d respectively, divide bilaterally into equal halves at the forty-cell stage or so, and produce

there two pairs of macromeres
at the future posterior half of
the blastula : one pair derived
from the first somatoblast is
denoted by X, respectively, de-
velops into the future shell gland
and others, and lies nearer to-
wards the animal pole. The
other pair derived from the
second somatoblast is called the
mesodermal' teloblasts, each of
which is denoted by M, and lies
nearer towards the vegetal pole
(Text-fig. 1).

These paired mesodermal
teloblasts migrate into the pos-
terior end of the blastocoel, and
become the paired mesodermal

Fig. 1

Text-fig 1. Section of marsupial sac of
gill, illustrating first and second somatoblasts
in blastulae. Photograph from specimen
stained by Mallory's connective tissue taining
method.   250   gf gill filament, M second
somatoblast or mesodermal teloblast, X first
somatoblast.

mother cells (Text-fig. 2). By repeating the cell-divisions they produce
many daughter cells throughout the blastula and gastrula stages. These
mesodermal daughters form the paired cell-masses grouped compactly
around the respective mesodermal mother cell. The primary mesoderm
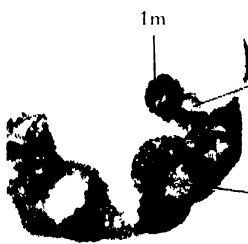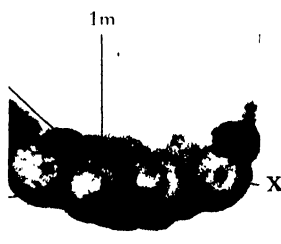
Fig. 2   Fig. 3   Fig 4

Text-fig. 2. Horizontal section of blastula, showing migration of teloblasts to posterior
end of blastocoel. ×600

Text-fig. 3. Horizontal section of later blastula, showing division of right mesodermal
cells. ×600.

Text-fig. 4. Horizontal section of later blastula, showing mesodermal mother cells and
their daughters. ×600.

Text-figs. 2-4 are photographed from specimens stained by Mallory's connective tissue
staining method. en endomere, M teloblast, 2M mesodermal mother cell, 1m first daughter
of mesodermal mother cell, 2m second daughter of mesodermal mother cell, X large de-
scendant from first somatoblast.

of this species in the blastula and gastrula is represented by these paired groups of the mesodermal cells, and develops in bilaterally symmetrical structures. The designation "mesodermal band," so-called from its appearance is not a suitable one for a group of these mesodermal cells but they may be called the "teloblastic cell-mass" of the mesoderm. The formation of each teloblastic cell-mass in this species is explained in Table 1.

The first division of each teloblast occurs during its migration into the posterior end of the blastocoel, and the small daughter $1m$ buds off at the inner, antero-ventral side of the mother cell 1M. After completion of the sinking of 1M and $1m$ into the blastocoel, the small daughter $2m$ buds off at the outer, anterior surface of 2M by the second division (Text-figs. 3, 4). Signs of gastrulation now appear in such a blastula (Pl. I, Fig. 1), and the third division of the mother occurs in the earliest gastrula, producing cells 3M and $3m$.[1] Its spindle is perpendicular to the outer,

TABLE 1

Cell-lineage of M in Sphaerium japonicum biwaense, illustrating formation of each teloblastic cell-mass of mesoderm.

Stage	Blastula		Gastrula				Fetal Larva
Number of Mesoderm cells	2	3	4	6	8	And so on	Countless
M	1M	2M	3M — 4M — 5M		N (3m) → N₁, N₂	Protonephridium; 6m → Pericardium, Heart, and Kidney; G₁ G₂ Germ cells; 5m → 4m → 4m₁, 4m₂; 2m₁, 2m₂; 1m₁ → 1m₁₁, 1m₁₂; 1m₂ → 1m₂₁, 1m₂₂	Mesenchymes, Myocytes, and Connective tissue cells
Diagram of teloblastic cell-mass	(1M)	(2M)	(3M)	(4M)	(5M, 7M, 6m)	right teloblastic cell-mass viewed from dorsal side	

[1] m is used to designate the daughter cells of a large size in distinction to *m*, which is used to designate those of a small size.

antero-dorsal surface of 2M (Text-fig. 5). 3m is larger than the other daughters but a little smaller than 3M, and develops into each future protonephridium.   Accordingly, 3m can be designated by N. N begins to move towards the antero-dorsal direction along the body wall with the progress of subsequent divisions. The fourth division produces 4M and 4m, and, synchronously to this division of the mother, 1m divides also into two equal cells, the dorsal $1m_1$ and the ventral $1m_2$. The fifth
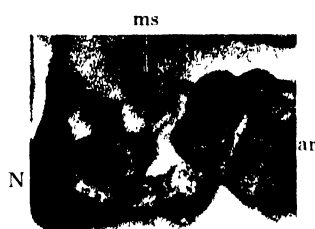
Fig. 5   Fig. 6

Text-fig. 5. Sagittal section, near median ventral portion, of early gastrula, showing separation of N from mesodermal mother cell. $\times 600$.

Text-fig. 6. Transverse section through ventral portion of gastrula, showing first division of N. $\times 600$.

Text-figs. 5 and 6 are photographed from specimens stained by Mallory's connective tissue staining method. ar archenteron, 2M third mitosis of mesodermal mother cell, ms daughters of mesodermal mother cell, N first mitosis of nephroblast N.

daughter 5m is, also, small as before, and lies at the outer, anterior surface of the mother 5M. On the other hand, 2m divides into two equal cells, $2m_1$ and $2m_2$. When the archenteron shows a sac-like depression at the ventral region, every remarkable mitotic figure is found, respectively, at the anterior and the posterior portion of each teloblastic cell-mass. The anterior one is of the first division of N (Text-fig. 6), and the posterior is of the sixth division of the mother cell 5M. The spindle of the latter is directed vertically to the mother cell (Pl. I, Fig. 2), and the daughter cell 6m is larger than those of the preceding small daughters, such as 1m, 2m, 4m and 5m.

In the succeeding stages, the archenteron shows a tubular structure, and its distal end extends posteriorly after the closure of the blastopore. In such a later gastrula, the mesodermal mother cell 6M appears to repeat its divisions and produces, at its postero-dorsal side, several cells, 7m, 8m, etc., as large as the sixth daughter 6m. The mother cell itself begins to move towards the inner, ventral portion of each teloblastic cell-mass.

Moreover, some of the daughters may divide into further descendants.

Thus, each teloblastic cell-mass increases in number of cells and develops into each half of the primary mesoderm of the fetal larva.[2] In conclusion, at the end of the gastrula stage, each teloblastic cell-mass consists of four kinds of mesodermal cells, viz. one mother cell, two protonephridial cells, several large daughters from the mother, and many small cells. Each mother cell loses its distinctness to some extent, owing to its own divisions, but retains a large vesicular nucleus with a distinct nucleolus among the mesodermal cells. After one division, each original cell of the protonephridium N produces the two cells, the outer N_1 and inner N_2, on the antero-dorsal end of the respective teloblastic cell-mass. The other mesodermal cells originating from each mother cell are divided into two groups. The large daughter, such as 6m, 7m, etc., are produced by later divisions of the mother, and are situated in contact with the ectodermal body wall, forming the postero-dorsal portion of each teloblastic cell-mass. The small daughters $1m$, $2m$, $4m$ and $5m$, produced by earlier divisions of the mother cell, are divided further into many small cells. These small cells are associated loosely with members of each teloblastic cell-mass in every portion of it. All these mesodermal cells are distinct from either the ectodermal or the endodermal cells.

CHANGES IN THE PRIMARY MESODERM IN THE FETAL LARVA STAGE.

In the process of development after the completion of gastrulation, the embryo reaches the fetal larva stage. In the middle of this stage, the rudimentary shell gland has already been invaginated at the posterodorsal portion of the larva, but, at the end of this stage, it is again spread over its whole dorsal area (OKADA, 1936). Therefore, the early fetal larva indicates the stage before the invagination of the shell gland, and the later fetal larva that after the reversion of the gland.

The primary mesoderm in the fetal larva, also, advances in differentiation in the bilaterally symmetrical structures (Pl. 1, Figs. 3, 5). The mesodermal cells increase in number not by any addition of ectodermal cells but by their own divisions (Text-figs. 7B, 9, 10, & Pl. I, Figs. 3C, 4B). The chief differentiations of the primary mesoderm, observed in this stage, are the formation of the primordial germ cells and of the protonephridia.

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[2] The fetal larva is the term used in my previous paper (OKADA, 1936) to express the young larval stage from the completion of gastrulation to the formation of the rudimentary shell.

Some cells of the primary mesoderm also in this stage, exhibit the appearance of mesenchymes. The remaining elements form a pair of cell-masses, which develop later into the heart, pericardium, and kidneys.
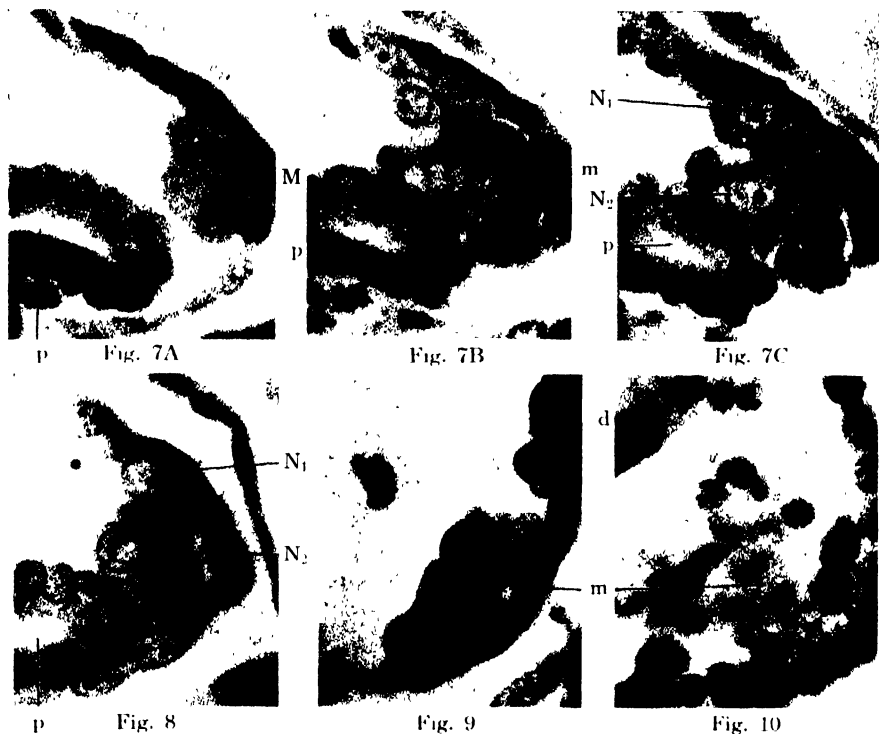
Text-fig. 7.   Three sagittal sections of earliest fetal larva, showing teloblastic cell-mass of mesoderm in its posterior halves. (A) section through mesodermal mother cell at innermost portion of teloblastic cell-mass, (B) section through middle portion of same, (C) section through N_1 and N_2 at outermost portion of same. > 600.

Text-fig. 8.   Left half of transverse section of earliest fetal larva, indicating N_1 and N_2.   ×600.

Text-fig. 9.   Posterior, right quarter of horizontal section of early fetal larva, showing mitotic figure of mesodermal cell at dorsal end of teloblastic cell-mass. ×600.

Text-fig. 10.   Posterior, right quarter of horizontal section of later fetal larva, showing mitotic figure and mesodermal cell in teloblastic cell-mass.   ×600.

Text-figs. 7 9 are photographed from specimens stained by Mallory's connective tissue staining method and Text-fig. 10 from specimen stained with boraxcarmine. d digestive deverticulum, M mesodermal mother cell, m mitotic figures of mesodermal cells, N_1 outer cell derived from N, N_2 inner cell derived from N, p primitive gut.

THE PRIMORDIAL GERM CELLS.

In the early fetal larva, after repeated cell-divisions (Text-fig. 7A), the mesodermal mother cell on either side of the primitive gut gradually recovers its distinctness, having a round vesicular nucleus which contains one or two nucleoli, and becomes the largest among the mesodermal cells, lying at the inner, ventral portion of the corresponding teloblastic cell-mass (Text-fig. 11C, & Pl. I, Figs. 3B, 4C, 5A). Each mesodermal mother cell in this condition can be designated the primordial germ cell, because the descendants produced by its subsequent divisions develop ultimately into the definitive germ cells. On the other hand, the differentiation of the primitive gut into the digestive diverticula, the stomach, and the intestine begins to be observed in this stage. The rudimentary intestine extends posteriorly along the median line, ventral to both teloblastic cell-masses, and unites with the posterior end of the ectodermal body wall forming the anal plate.

In the stage of the fetal larva with invaginated shell gland, the anal plate opens to the exterior by the formation of the proctodaeum. A remarkable growth of the posterior region of the larva in this stage moves the anus from the posterior to the ventral side of the larva, and the posterior intestine begins to show a bending downwards between both teloblastic cell-masses. At the same time, the mesodermal cell-masses extend ventro-laterally in agreement with the growth of the posterior body wall. Thus, the relative position between the teloblastic cell-masses and the posterior intestine is being transformed into the definitive condition, i. e. each primordial germ cell is beginning gradually to lie on the respective outer, ventral side of the rectum.

In the later stage of the fetal larva, each primordial germ cell undergoes the first equal division. The spindle of this division takes an inner, ventral direction (Pl. I, Fig. 6). These two primordial germ cells seem to enter the period of inactivity until the second stage of the prodissoconch-larva[a] (OKADA, 1938). While approaching the latest stage of the fetal larva, they begin to appear very large in comparison with the surrounding cells, and can easily be distinguished on the inner, anterior side of the rudiment of each kidney[b] (Text-fig. 16, & Pl. I, Fig. 7).

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[a] The prodissoconch-larva is the term used in my previous paper (OKADA, 1938) to express the larval stages after the fetal larva stage till delivery. Its development is divided into three stages, mainly according to size, i. e. the first stage 0.25–0.3 mm., the second 0.3–0.5 mm., and the third more than 0.5 mm. in antero-posterior length.

[b] The development of the kidney will be described later.

THE PROTONEPHRIDIA.

In the early fetal larva, N_1 and N_2 on either teloblastic cell-mass lengthen and reach about the level of the digestive diverticula. The outer one N_1 lies in close contact with the ectodermal body wall. Its cytoplasm is elongated from the antero-dorsal to the postero-ventral direction. Its vesicular nucleus with a distinct nucleolus is located anteriorly in this elongated cytoplasm (Text-figs. 7C, 8). Meanwhile, the elongated N_1 acquires a central lumen, which begins to extend postero-ventrally towards the ectodermal body wall (Pl. 1, Fig. 3A). A few mesenchymal elements are seen between N_1 and N_2.

In the stage of the fetal larva with invaginated shell gland, N_1 becomes

Fig. 11A   Fig. 11B
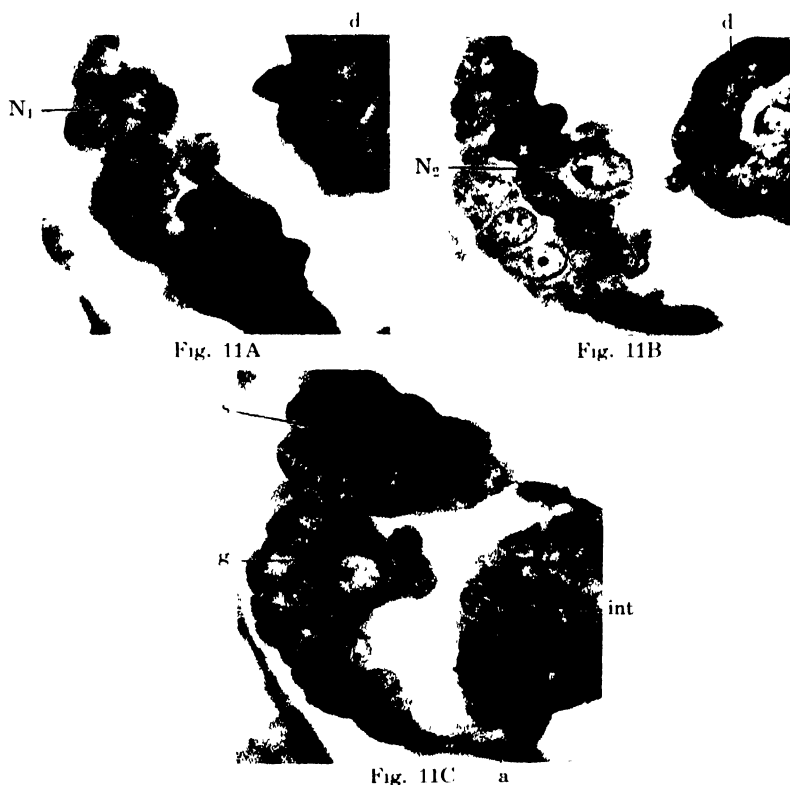
Fig. 11C   a

Text-fig. 11. Three sagittal sections of fetal larva with invaginated shell gland, showing two original cells of protonephridium and primordial germ-cell at posterior, dorsal part of larva. Photograph from specimen stained by Mallory's connective tissue staining method. ×600. (A) section through N_1, (B) same through N_2, (C) same through primordial germ cell. a anus, d digestive diverticulum, g primordial germ cell, int intestine, N_1 outer cell derived from N, N_2 inner cell derived from N, s shell gland.

clearer owing to its elongation and to the presence of the lumen. N_1 now penetrates the body wall, and opens to the exterior, indicating the signs of differentiation into the excretory tubule of the corresponding protonephridium (Text-fig. 11A, & Pl. I, Figs. 4A, 5B). N_2 becomes also clearer owing to its own expansion, containing a vesicular nucleus (Text-fig. 11B, & Pl. I, Figs. 4B, 5B). The mesenchymal elements between N_1 and N_2 somewhat increase in number as compared with those in the previous stages. These mesenchymal elements may originate from N_2 or derived from larval mesoblasts. No positive statement can be made as to this suggestion. In this stage, the distinctness of N_2 is apt to be taken for that of the primordial germ cell. In the detailed observation, however, N_2 lies on the inner, anterior portion of each mesodermal cell-mass, while the germ cell is found on the inner, ventral portion of it, being surrounded by some mesodermal elements (Text-fig. 11C, & Pl. I, Figs. 4C, 5A). Moreover, the nucleus of N_2 is rather smaller than that of the germ cell, and the cytoplasm of the former is thinner than that of the latter.

At the end of the stage of the fetal larva with the invaginated shell gland, the mesenchymal elements between N_1 and N_2 are dispersed, and N_2 comes near again to N_1 at its dorsal side (Text-figs. 12, 15A). Meanwhile, N_2 divides nearly vertically into two equal cells, the anterior aN_2
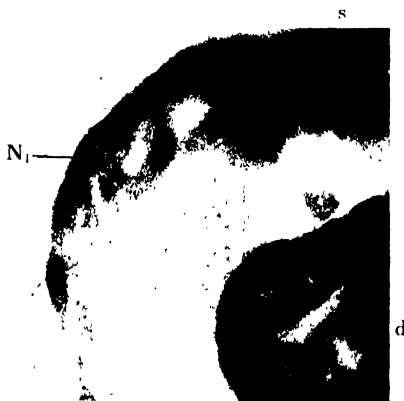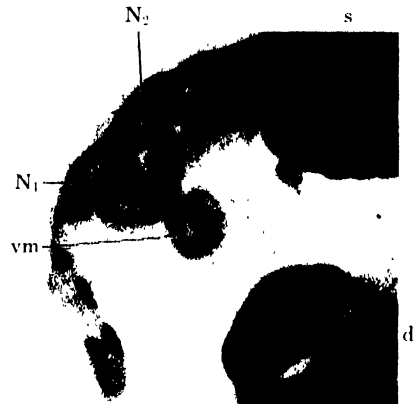
Fig. 12A   Fig. 12B

Text-fig. 12. Two serial horizontal sections of later fetal larva with invaginated shell gland, showing derivatives from N in posterior side of left digestive diverticulum. Photograph from specimen stained by Mallory's connective tissue staining method. ×600. (A) section through developing excretory tubule of protonephridium, (B) same through N_2 and dorsal side of excretory tubule. d digestive diverticulum, N_1 outer cell derived from N forming excretory tubule, N_2 inner cell derived from N, s shell gland, vm vacuolated mesenchyme cell.

and the posterior pN_2. These two cells remain small without regaining the measurement of the mother, and extend antero-dorsally, in the result forming there two elongated cells (Text-fig. 15B). On the other hand, N_1 also extends antero-dorsally and becomes a large cell lying outside of the digestive diverticula. A large vesicular nucleus with a distinct nucleolus lies in the anterior end of this large cell. Its intra-cellular lumen extends and differentiates into the excretory tubule of the protonephridium.

In the latest stage of the fetal larva, aN_2 becomes connected with the excretory tubule of the protonephridium. A tuft of cilia begins to appear on the surface of attachment of aN_2 to N_1 and lengthens into the lumen of the excretory tubule. Thus, aN_2 shows the differentiation into the primary flame cell (Text-figs. 13, 15C), and in this condition, each protonephridium is functional. In the immediately succeeding stage, another cell pN_2, which lies at the inner, postero-dorsal side of the primary flame cell, is differentiated into the posterior or secondary flame cell. Many distinct granules begin to appear in the wall of the excretory tubule of the protonephridium.

In process of development, the fetal larva develops into the prodisso-

Fig. 13   Fig. 14A   Fig. 14B

Text-fig. 13. Obliquely transverse section, showing left protonephridium of later fetal larva. Photograph from specimen stained by Mallory's connective tissue staining method. ×600. *d* digestive diverticulum, *ex* excretory tubule, *pf* primary flame cell, *sf* secondary flame cell.

Text-fig. 14. Two serial transverse sections of early prodissoconch-larva, showing full development of right protonephridium. Photograph from specimen stained by Auerbach's method. ×600. (A) section through large cell forming excretory tubule of protonephridium, (B) section through secondary flame cell. *d* digestive diverticulum, *ex* excretory tubule, *pl* pleural ganglion, *sf* secondary flame cell.

conch-larva (OKADA, 1938). In this earliest prodissoconch-larva, the primary
flame cell is degenerating, and the secondary flame cell enters complete
differentiation in turn. The large cell, forming the excretory tubule and
containing many granules, indicates the full development (Text-figs. 14,
15D). Thus, each protonephridium in this stage develops into its highest
differentiation as a whole, and is composed of a functional flame cell

Fig. 15A   Fig. 15B   Fig. 15C   Fig. 15D
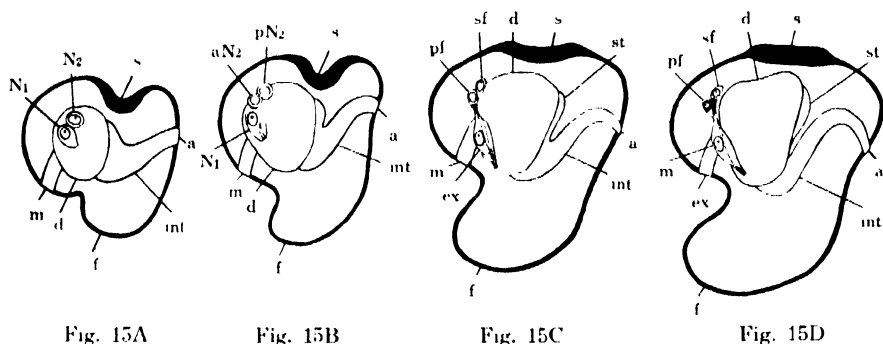
Text-fig. 15. Four schematic representations, illustrating development of left
protonephridium. × 150. (A) protonephridial cells in fetal larva with invaginated
shell gland. (B) same in later fetal larva with invaginated shell gland, (C) same in
latest fetal larva after reversion of shell gland, (D) same in earliest fetal larva. *a*
anus, *aN₂* inner anterior cell derived from *N₂*, *d* digestive diverticulum, *ex* excretory
tubule of protonephridium, *f* foot, *int* intestine, *m* mouth, *N₁* outer cell derived from
N, *N₂* inner cell derived from N, *pf* primary flame cell, *pN₂* inner posterior cell
derived from N₂, *s* shell gland, *sf* secondary flame cell, *st* stomach.

and an excretory tubule. In such, the highest, differentiation, the flame
cell measures about 15 μ long and 8 μ wide, its nucleus being about 10 μ
long and 6 μ wide. The excretory tubule measures about 50 μ long and
15 μ wide, its nucleus being about 15 μ long and 10 μ wide. The proto-
nephridia of both sides of the larva are a vestigial organ, which degener-
ates in the stage of the early prodissoconch-larva.

THE MESENCHYMES.

In the gastrula stage, the small cells from the mesodermal mother cell
are scattered loosely near the teloblastic cell-masses and form mesenchymes
of the fetal larva. Other mesenchymes derived from the larval mesoblasts
are, also, scattered in the anterior portion of the larva. These two kinds
of mesenchyme, however, cannot be clearly distinguished by their apparent
characters.

In the stage of the fetal larva with invaginated shell gland, the mesen-

chymal elements are scattered in almost every portion of the body, being especially abundant in the anterior and ventral regions of the teloblastic cell-masses. Many of the elements show a spindle shape, each having an elongated nucleus, or a small round shape, each having a nucleus rich in chromatin. They increase in number by their own divisions. As stated above, several mesenchymes near the outer and inner protonephridial cells are, also, appearing in this stage, and the vacuolated round cells are often observable among them (Text-fig. 12B, & Pl. I, Figs. 4C, 6).

The precise tracing of the lineage of these mesenchymal elements is impossible owing to their complicated ordinations. At any rate, it seems to be true that the derivatives of the small cells from the mesodermal mother cell and those from the larval mesoblasts develop into the greater part of the mesenchymes. In the latest stage of the fetal larva, the vacuolated elements of the mesenchymes are scarcely found, and the spindle-shaped elements have greatly increased in number. Some members of the latter lie in close contact with the ectodermal body wall or with the outside of the alimentary cannal. The other members are scattered in the blastocoel. The interior of the growing foot is furnished with large numbers of this kind of mesenchyme.

In the stage of the prodissoconch-larva, these mesenchymes develop into connective tissue cells or into future muscular cells, as stated in the previous paper (OKADA, 1938).

APPEARANCE OF THE RUDIMENTARY KIDNEYS FROM PAIRED PRIMI-
TIVE ANLAGES OF THE HEART, PERICARDIUM AND KIDNEYS.

In the stage of the fetal larva, the large derivatives from the respective mesodermal mother cell are somewhat indistinguishable from the small derivatives. The group of the large derivatives, however, remains in a compact mass, and forms the greater part of each teloblastic cell-mass of the fetal larva on either side of the posterior intestine. The elements of each compact cell-mass are usually furnished with the roundish nuclei. However, no further differentiation is yet observable, except the increase of the members by their own divisions, but not by the addition of the ectodermal cells. The compact masses of the mesodermal cells on both sides of the posterior intestine are the primitive anlages of the heart, pericardium and kidneys.

In the latest stage of the fetal larva, the posterior elements of each anlage on either side of the rectum become detached from the remainder, and begin to form a tubular arrangement on the outer, posterior portion

of two primordial germ cells (Pl. I, Fig. 7). This tubular cell arrangement represents the rudiment of each kidney, and is composed of cubical cells with vesicular nuclei (Text-fig. 16). But this structure is somewhat obscure in this stage, because at its ventral side the ectodermal cells are proliferating and forming the respective visceral ganglion. The remainder of each mesodermal cell-mass becomes elongated dorsally, and the members become scattered somewhat loosely on the outer, antero-dorsal side of the two primordial germ cells (Pl. II, Fig. 8). Each group of these mesodermal cells may be called the cardiac cell-mass, and develops into the future heart, pericardium, and perhaps into some vascular cells, but at this stage is still undifferentiated.

Text-fig. 16. Horizontal section of latest fetal larva, showing rudiment of left kidney. Photograph from specimen stained by Mallory's connective tissue staining method. ×600. *d* digestive diverticulum, *g* primordial germ cell, *hp* cardiac cell-mass, *k* rudiment of kidney, *r* rectum, *st* stomach.

FORMATION OF THE HEART, PERICARDIUM, AND KIDNEYS IN THE EARLY PRODISSOCONCH-LARVA.

The primordial germ cells, the rudiments of the kidneys and the cardiac cell-masses, observed in the latest fetal larva, develop, respectively, into the definitive organization in the stages of the prodissoconch-larva. The outline of development of these organs has already been given in the previous paper (OKADA, 1938). In the first stage of the prodissoconch-larva, the heart, the pericardium, and the kidneys begin to form, while the two primordial germ cells on either side of the posterior intestine remain unchanged in number and in appearance. In the second stage, the formation of the heart, of the pericardium and of the kidneys is nearly completed. The primordial germ cells, which are attached to the antero-ventral surface of each rudimentary pericardium, begin to multiply and form proper cells of the definitive gonad. Further growth of the heart, of the pericardium and of the kidneys is, of course, continued even in the later stages of the prodissoconch-larva. In the present investigation, however, the observations were limited to the formation of the heart, of the pericardium and of the kidneys in the early prodissoconch-larva.

APPEARANCE OF THE RUDIMENTARY PERICARDIAL CAVITIES,
AND THE FORMATION OF THE HEART AND PERICARDIUM.

In the earliest stage of the prodissoconch-larva, each cardiac cell-mass mentioned above becomes rearranged *in situ* so as to surround a small cavity, which indicates the coelom apart from the blastocoel. This cavity is the first appearance of each half of the future pericardial cavity, and lies just outside each mass of the primordial germ cells. Its contour is an ill-formed cone extending dorsally. The mesodermal elements constituting this wall are grouped densely, to some extent, at its base adjoining the primordial germ cells, while they are flattened, and form a thin layer near its·dorsal end (Text-fig. 17).

Fig. 17A
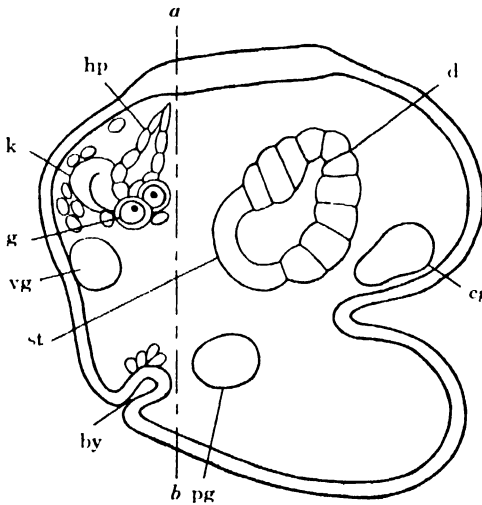
Fig. 17B
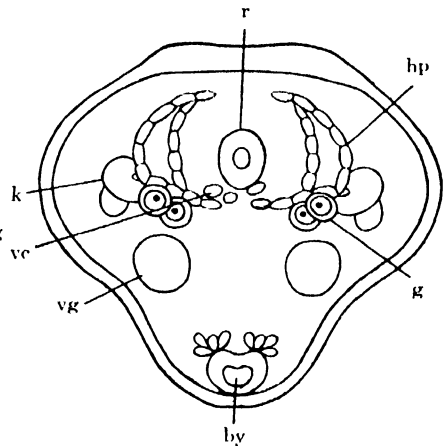
Text-fig. 17. Schematic representations of earliest prodissoconch-larva, about 0.25 mm. long, illustrating formation of heart, pericardium and kidney. ×230. (A) right side view, (B) anterior side view through *ab* in (A). *by* byssal gland, *cg* cerebro-pleural ganglion, *d* digestive diverticulum, *g* primordial germ cell, *hp* cardiac cell-mass, *k* kidney, *pg* pedal ganglion, *r* rectum, *st* stomach, *vc* vascular cell, *vg* visceral ganglion.

Meanwhile, each rudimentary pericardial cavity grows to a crescent-shape, in cross-section, by its own growth towards the inner, dorsal and ventral directions, and begins to surround the rectum at a considerable distance. At first, the cells of the inner end at the base project towards the median line of the body beneath the rectum, and form a cell-sheet along the postero-dorsal side of the primordial germ cells. Then, the cavity itself extends into this projecting cell-sheet. Moreover, some vas-

cular cells, which are perhaps the cells delivered from the cell-sheet, appear and come to lie scattered round the rectum (Text-figs. 17, 18). The dorsal end of the rudimentary pericardial cavity extends also towards the median line in the same manner as at the ventral end.
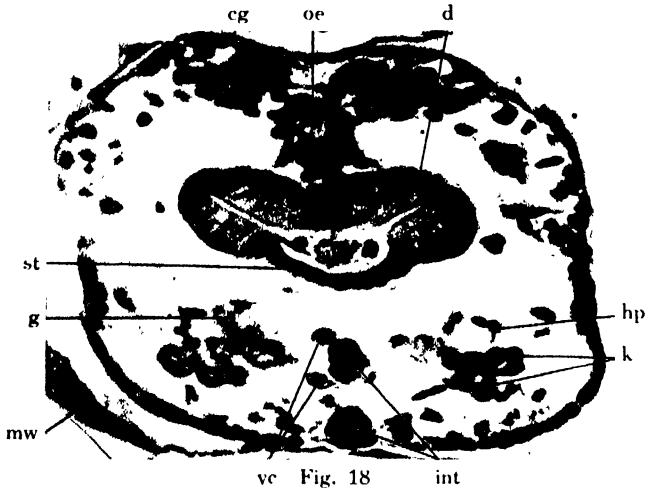
Text-fig. 18. Horizontal section of earliest prodissoconch-larva, about 0.25 mm. long, showing formation of heart, pericardium and kidneys. Photo-graph from specimen stained by Auerbach's staining method. ×250. cg left cerebro-pleural ganglion, d right digestive diverticulum, g primordial germ cell, hp rudiment of heart and pericardium, int posterior intestine, k kidney, mw wall of marsupial sac of mother, oe oesophagus, st stomach, vc vascular cells.

On the other hand, the posterior growth of each rudimentary cavity is, also, generated at both dorsal and ventral ends of it. By this posterior growth, the dorso-posterior and ventro-posterior ends are united with each other (Text-fig. 19). Therefore, this part of each rudimentary pericardial cavity assumes a ring-shape, a bridge remaining at its center, which con-nects its inner and outer parts. At the same time, the paired rudimentary pericardial cavities connect with each other at the dorsal and ventral sides of the rectum by the process of their dorsal and ventral growths. Of these two connections of both cavities, the completion of the ventral one is a little earlier than that of the dorsal. The rectum and some vascular cells become thus confined by the inner wall of the pericardial cavity. During these processes, the cells forming the walls of the pericardial cavity become increasingly flattened, and the newly extended portions of the cavity form lamellar spaces between the outer and inner walls.

In the second stage of the prodissoconch-larva, some of the vascular

cells included by the inner wall of the pericardial cavity are rearranged and form an endothelium outside the intestinal wall. A space surrounded by the endothelium on one side is then joined to that on the other by the dorsal and ventral connections, as in the case of the pericardial cavity, and this union of the spaces forms there a heart chamber round the rectum. The completed heart, therefore, consists of the median ventricle with the anterior and posterior passages and both lateral auricles developed in connexion with the lateral bridges mentioned above (Pl. II, Figs. 9, 10, 12). The pericardium extends, especially in the ventral direction. The pericardial cavity assumes an inverted conical shape surrounding the heart and forms paired urino-pericardial openings at its ventral end (Pl. II, Fig. 13).
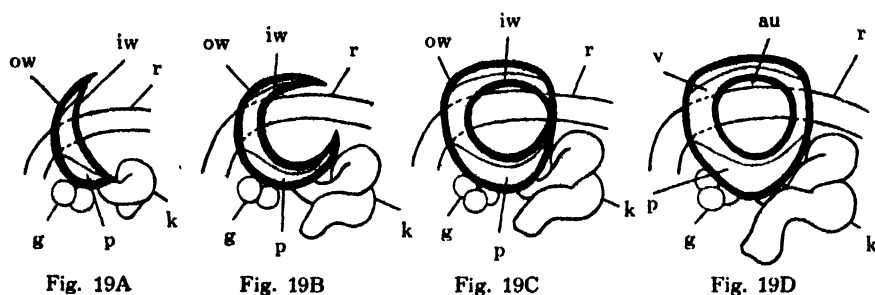
Fig. 19A Fig. 19B Fig. 19C Fig. 19D

Text-fig. 19. Schematic illustrations of heart, left rudimentary pericardial cavity, and left kidney of early prodissoconch-larva, showing their development. (A) schema, in larva about 0.25 mm. long, (B) same, in larva about 0.3 mm. long, (C) same, in larva about 0.35 mm. long, (D) same, in larva about 0.4 mm. long. × 300. *au* auricle of heart, *g* germ cells, *iw* inner and posterior walls of rudimentary pericardial cavity, *k* kidney, *ow* outer and anterior walls of pericardial cavity, *p* pericardial cavity, *r* rectum, *v* ventricle of heart.

FORMATION OF THE KIDNEYS.

As stated above, each rudimentary kidney, which is formed of some of the cells of each teloblastic mesoderm, showed an indication of a tubular arrangement in the fetal larva in the latest stage (Text-fig. 16). In the stages of the prodissoconch-larva, this rudiment develops and forms the excretory organ or kidney. In the earliest prodissoconch-larva, which measures about 0.25 mm. in antero-posterior length, each kidney, which has formed near the ventral end of the respective pericardial cavity, extends posteriorly, and then in being extended turns abruptly in the antero-ventral direction. This kidney, therefore, assumes a ꟼ-shaped loop formation in a lateral view, and acquires a lumen in its interior. But, in this stage neither end of the kidney is yet open. The walls of this developing

organ are constituted of cubical cells and furnished with round nuclei, which are easily distinguishable from the others (Text-fig. 18).

In the stage when the larva measures about 0.3 mm. long, the lumen of the kidney begins to open to the exterior. Its outer end extends further antero-ventrally, passes over the respective developing visceral ganglion, and then finally opens to the outside of the body, thus developing into the future cloacal chamber inside the gill. The inner end of each kidney, also, opens to the pericardial cavity at its ventral end. By this time, each kidney has become differentiated definitively into a winding, tubular organ (Text-fig. 19).

In the next stage, each kidney advances in differentiation through its own growth, and undergoes several convolutions at the respective side of the rectum, posterior to the pericardial cavity (Pl. II, Fig. 11).

DISCUSSION

In the great majority of Mollusca, the primary mesoderm is formed by the teloblastic method. Besides this, two other methods of formation of the primary mesoderm have been reported as occurring in some species of Mollusca, viz. the enterocoelic method in *Viviparus viviparus* and the meso-ectoblastic method in the species of heavily yolked eggs. The teloblastic and enterocoelic methods are related to one another, and may be considered to be the meso-endoblastic method. In the species under discussion, there is no doubt that the primary mesoderm is formed by the teloblastic method, by which the mesoderm originates as cell 4d from the endoderm. The validity of this method is confirmed in the case of almost all the Lamellibranchia. In the case of *Ostrea edulis*, FERNANDO (1931) describes the teloblastic method of the mesoderm formation, which coincides well with my account in the case of *Sphaerium japonicum* given in the present paper.

The protonephridia, the primordial germ cells, the kidneys, the heart, and the pericardium are derived from the teloblastic cell-masses. Some earlier investigators, however, do not always accept the information regarding these mesodermal derivatives.

As to the protonephridia of Lamellibranchia, various investigations have up to the present been made and in every case observed, each protonephridium has been found to be a vestigial organ, which appears only in the larval stage, and degenerates in the adult. As to its structure as reported hitherto, however, there is a difference in the conclusion formed

by each investigator. One of the most trustworthy observations of the structure is reported by MEISENHEIMER (1901 a) in the case of *Dreissensia polymorpha.* His description agrees well with the result found in the present observation made by myself. A comparison of ZIEGLER's description (1885) of *Cyclas cornea* (=*Sphaerium corneum*) with mine will leave no doubt as to the identity of the protonephridia in the two descriptions. But his observation was not thorough enough, and so is unsatisfactory. On the other hand, STAUFFACHER (1898) reported a complicated structure in the case of the protonephridium of *Cyclas* and an unpaired occurrence of it, which he found only on the left side of the larva. This description of STAUFFACHER's may, however, be based on defective observation on his part.

Many opinions regarding the origin of the protonephridia are grouped under the following three types: the first is the mesodermal origin, the second the ectodermal, and the third both a mesodermal and an ectodermal origin. MEISENHEIMER supported the ectodermal origin, though he added that in his observation he had some difficulty making this decision. Moreover, several investigators stated that the protonephridia were formed by the cells migrating from the ectoderm near the head vesicle. STAUFFACHER and some others have maintained that the principal portion of the protonephridium was mesodermal in origin, but that the excretory tubule was ectodermal. None of these opinions is correct. In fact, the origin of the protonephridia is liable to be misjudged, because the protonephridial cells are in close contact with the ectoderm after the stage of the later gastrula, and various transformations of the mesenchyme cells occur near these protonephridial cells. In spite of his precise description of the structure of the protonephridia, MEISENHEIMER also mistook their origin owing to his incomplete investigation of them in the early gastrula stage. A thorough and careful investigation, however, would show that each protonephridium, including both flame cells and excretory tubule, is formed of the cells derived from each teloblastic cell-mass of mesoderm. WIERZEJSKI (1905) investigated thoroughly the mesodermal bands on *Physa fontinalis,* and describes his mesodermal nephroblasts as the original cells of the protonephridia. ZIEGLER and several authorities, also, explain the origin of the protonephridia as mesodermal, though their explanation is very incomplete.

Some parts of the mesenchymes and of the myocytes seem to be derived from the teloblastic cell-masses. But, it is difficult to trace the details of the lineage of these elements. The primordial germ cells, also,

are formed in the teloblastic cell-masses. Almost all investigators, hitherto, have recognized that these primordial cells are the lineal descendants of the so-called "mesodermal mother cell." WOODS (1931, '32) describes the developmental features of these primordial cells in the case of *Sphaerium striatinum*.

The remaining elements of the teloblastic cell-masses are concerned with paired primitive anlages of the heart, pericardium and kidneys. As stated already, MEISENHEIMER (1901 a & b) and HARMS (1909) suggested the ectodermal origin of these primitive anlages, maintaining that these anlages are not formed by mesodermal cells but by an outgrowth of the ectoderm, and from the cells forming the mesodermal strands are derived the muscular system and the connective tissues. To this opinion, FERNANDO (1931) expresses the following objection: "On examination of MEISEN-HEIMER's description of the development of the pericardium in *Sphaerium* and that of HARMS it appears probable that both of them state with the stages after completion of gastrulation. We have shown that in this stage the ectodermal nature of the pericardial rudiments is a superficial appearance, because it is only in these later stages that the mesoderm comes to lie against the ectodermal wall; in earlier stages the cell boundaries are distinct, in later stages they are obscure causing difficulties in interpretation." My present investigation of *Sphaerium japonicum* gives confirmation to FERNANDO's statement. Most of the investigators, such as ZIEGLER, LILLIE, AHTING, HERBERS, etc., also, support the mesodermal nature of the heart, pericardium and kidneys. Thus, the developmental fate of the teloblastic cell-masses in the Lamellibranchia bring this group into line with the other Mollusca.

The processes in the formation of the heart, pericardium and kidneys, however, remain to be determined. In *Sphaerium*, the formation of the three occurs in the order of kidneys, pericardium, heart. Concerning the formation of the heart and pericardium, two different statements are offered by ZIEGLER (1885) and MEISENHEIMER (1901 b). ZIEGLER asserts that paired rudiments of the pericardial cavity, which appear at both sides of the rectum, unite with each other on the median plane, and form the heart and pericardium surrounding the rectum. According to MEISEN-HEIMER, paired primitive anlages of the future heart and pericardium are produced on both sides of the rectum, and then two splits, the dorsal and the ventral, appear in each anlage. Therefore, each rudimentary pericardial cavity is divided into the dorsal and ventral halves from the start, and the partition between the dorsal and ventral splits in each

anlage develops into each future auricle.

In the other species of Lamellibranchia, also, the process of the formation of the heart and pericardium has been reported in detail. MEISENHEIMER (1901 a) observes in regard to *Dreissensia*, that the kidneys are differentiated at first and, next, the heart and pericardium from the primitive anlages, and that the pericardial cavity is formed by two rudiments starting from the dorsal and the ventral side of the rectum. HERBERS (1914) reports the same process in the case of *Anodonta* as in that of *Dreissensia* reported by MEISENHEIMER, FERNANDO (1931) observes, with regard to *Ostrea*, that from the primitive anlages at first the heart and pericardium and then the kidneys differentiate, and that the pericardial cavity is formed by two rudiments starting from both left and right sides of the rectum.

Thus, these descriptions regarding time and modus of differentiation into the heart, pericardium and kidneys from the primitive anlages vary to some extent according to different species. In conclusion, the primary mesoderm of *Sphaerium japonicum* develops into the teloblastic cell-masses separated from the ectodermal and the endodermal organ system, and gives rise to the primordial germ cells, to the protonephridia, to the kidneys, to the heart and pericardium, and to some cells of the connective tissue.

SUMMARY

(1) The present paper gives a detailed description of the development of the primary mesoderm of *Sphaerium japonicum biwaense* MORI, with special reference to the formation of the protonephridia, primordial germ cells, kidneys, heart and pericardium.

(2) A table is given, showing the early genealogy of the cells of each teloblastic cell-mass of mesoderm in the blastula and gastrula stages.

(3) The primary mesoderm develops and grows by its own cell-divisions in the larval stages. No addition of ectodermal cells to the teloblastic cell-masses is observable.

(4) The primordial germ cells, the protonephridia, the kidneys, the heart and pericardium, and some connective tissue cells are derived from the primary mesoderm in the larval stages.

(5) The primordial germ cells are the lineal descendants of the teloblasts or the mesodermal mother cells of the primary mesoderm.

(6) Each protonephridium is derived from a cell of the primary

mesoderm.   The inner cell, which is a derivative of the protonephridial cell, develops into the primary and secondary flame cells and the outer one into the excretory tubule.

(7) After the separation of the protonephridial cells, mesenchymes, and germ cells, the primary mesoderm develops as a pair of the primitive anlages of the kidneys, heart and pericardium.

(8) Each rudiment of the kidneys is differentiated from the respec-tive primitive anlage, the cardiac cell-mass remaining there.

(9) The rudimentary pericardial cavity appears first in each cardiac cell-mass.

(10) The rudimentary pericardial cavities on both sides of the rectum are enlarged by their dorsal, ventral and posterior growths and unite with each other surrounding the rectum.

(11) The outer walls of both rudimentary pericardial cavities make the pericardium, and their inner walls the outer wall of the heart.

(12) Vascular cells included by the inner walls of both rudimentary pericardial cavities are rearranged in the endothelium of the heart, which is a median ventricle with both lateral auricles.

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EXPLANATION OF PLATE I

Fig. 1. Sagittal section of blastula at its latest stage, showing right mesodermal mother cell and its daughters. ×300.

Fig. 2. Sagittal section of gastrula at its early stage through right teloblastic cell-mass, showing mitotic figure of sixth division of mesodermal mother cell. ×300.

Fig. 3. Three serial horizontal sections of early fetal larva, showing bilaterally symmetrical structure of teloblastic cell-masses of mesoderm. ×300.
(A) section through protonephridial cells, (B) section through mesodermal mother cells, (C) section through postero-ventral portions of teloblastic cell-masses.

Fig. 4. Three serial sagittal sections of fetal larva with invaginated shell gland, showing left teloblastic cell-mass of mesoderm. ×300.
(A) section through outer protonephridial cell, (B) section through inner protonephridial cell, (C) section through primordial germ cell.

Fig. 5. Two serial, obliquely transverse sections of fetal larva with invaginated shell gland, showing bilaterally symmetrical structure of teloblastic cell-masses of mesoderm. ×300.
(A) section through primordial germ cells, (B) section through protonephridial cells.

Fig. 6. Obliquely transverse section of later fetal larva through developing proto-nephridia and primordial germ cells, showing mitotic figure of first equal division of left primordial germ cell. ×300.

Fig. 7. Horizontal section of latest fetal larva, showing primordial germ cells, rudiments of kidneys, and cardiac cell-masses. ×300.

ABBREVIATIONS IN PLATE I

ar	archenteron		many divisions
ap	anal plate	N	protonephridial cell
bl	blastocoel	on	outer protonephridial cell
d	digestive diverticulum	pf	primary flame cell
en	endoblast beginning to form arch-enteron	r	rectum
		s	shell gland
ex	cell forming excretory tubule of protonephridium	st	stomach
		tm	teloblastic cell-mass of mesoderm
g	primordial germ cell	vm	vacuolated mesenchymal cell
gd	mitotic figure of equal division of germ cell	lm	mitotic figure of division of first daughter from mesodermal mother cell
hp	cardiac cell-mass		
in	inner protonephridial cell	2M	mesodermal mother cell after second division
int	intestine		
k	rudiment of kidney	5M	mitotic figure of sixth division of
Mc	mesodermal mother cell after		mesodermal mother cell

Fig. 1
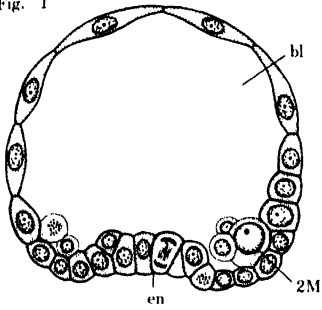
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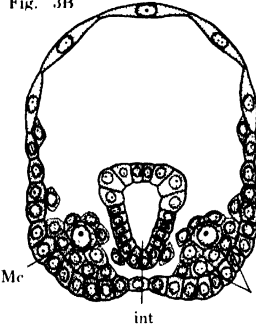
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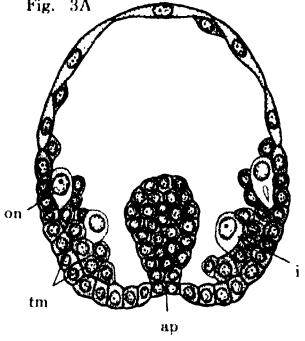
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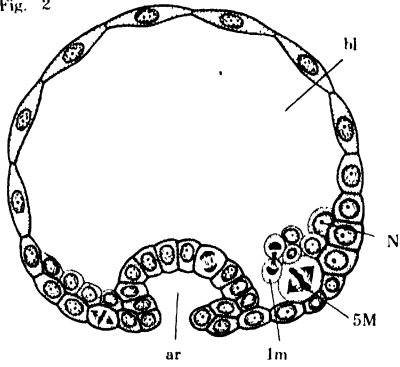
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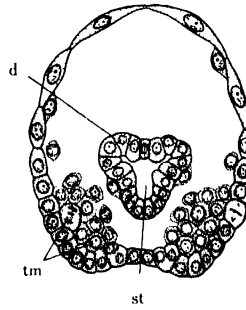
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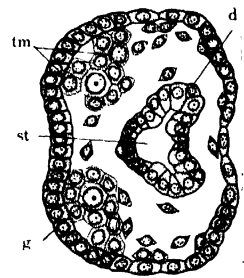
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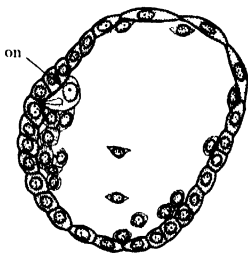
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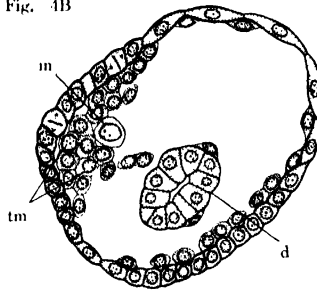
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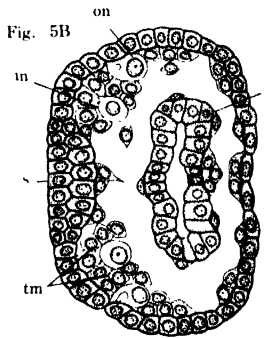
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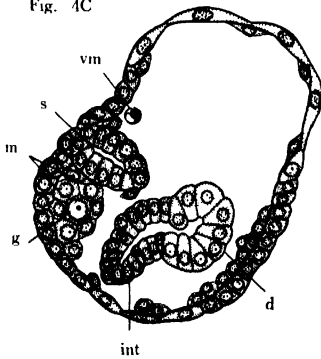
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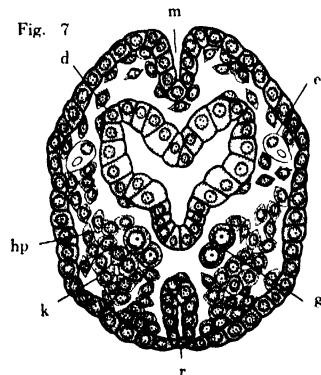
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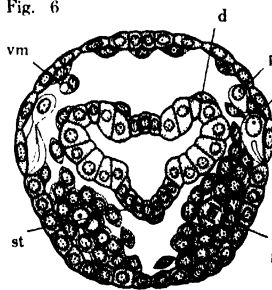
EXPLANATION OF PLATE II

Fig. 8. Sagittal section near median of latest fetal larva, showing rudiment of kidney, cardiac cell-mass and primordial germ cell.   × 150.

Fig 9. Transverse section of pro-lissoconch-larva, 0.4 mm long, through heart and visceral ganglia, showing development of heart and pericardium   × 150.

Fig. 10. Transverse section of prodissoconch-larva, 0.4 mm. long, through heart and ventral end of stomach, showing development of heart and pericardium.   × 150.

Fig. 11. Transverse section of prodissoconch-larva, 0.4 mm. long, through kidneys and byssal gland, showing structure of kidney.   × 150.

Fig. 12. Horizontal section of prodissoconch-larva, 0.45 mm. long, through heart, showing structures of heart and pericardium.   × 150.

Fig. 13. Nearly median, sagittal section of prodissoconch-larva, 0.45 mm. long, showing structures of heart and pericardium.   · 150.

ABBREVIATIONS IN PLATE II

au	auricle of heart	*lp*	lower part of pericardium
by	byssal gland	*p*	pedal ganglion
cg	cerebral ganglion	*pk*	urino-pericardial duct of kidney
d	digestive diverticulum	*r*	rectum
ek	external opening of kidney	*st*	stomach
g	primordial germ cell	*up*	upper part of pericardium
gf	gill filament of mother	*v*	ventricle of heart
gi	rudimentary gill	*vc*	vascular cell
hp	cardiac cell-mass	*vg*	visceral ganglion
k	kidney		

K. OKADA : Primary Mesoderm in Sphaerium japonicum.
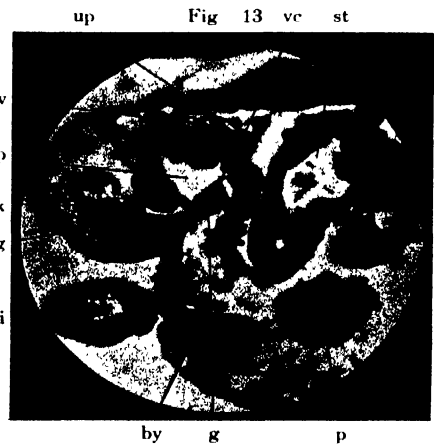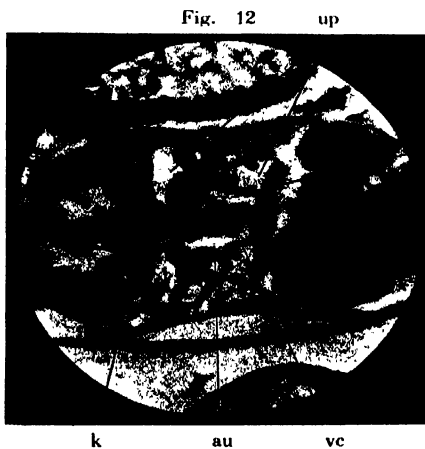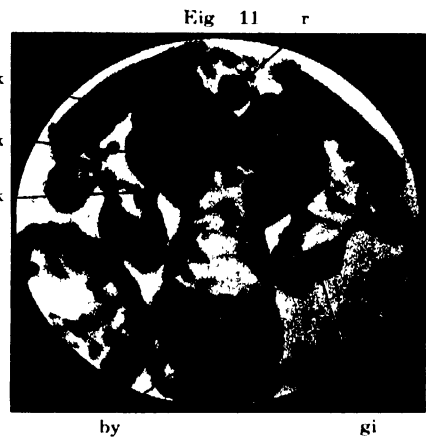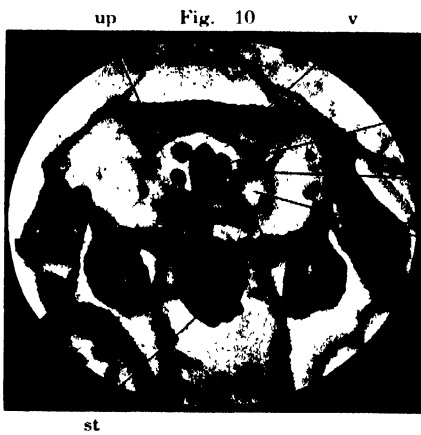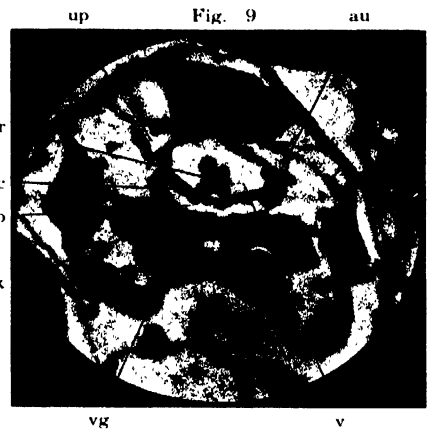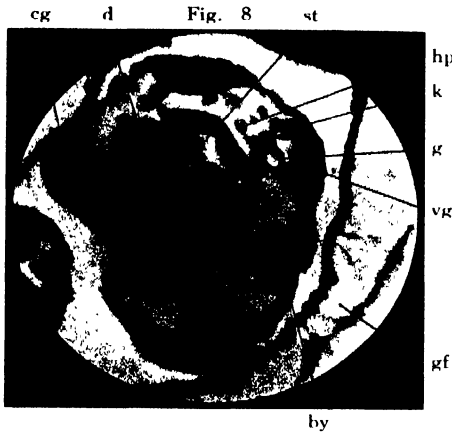
trennen sich aber nie von der Mutterpflanze ab.*

Die zweiten Brutkörper sind kleine, verkehrt eiförmige Gebilde. Sie sind meistens 2 mm, nur selten 5 mm, lang. Sie entstehen zuerst als
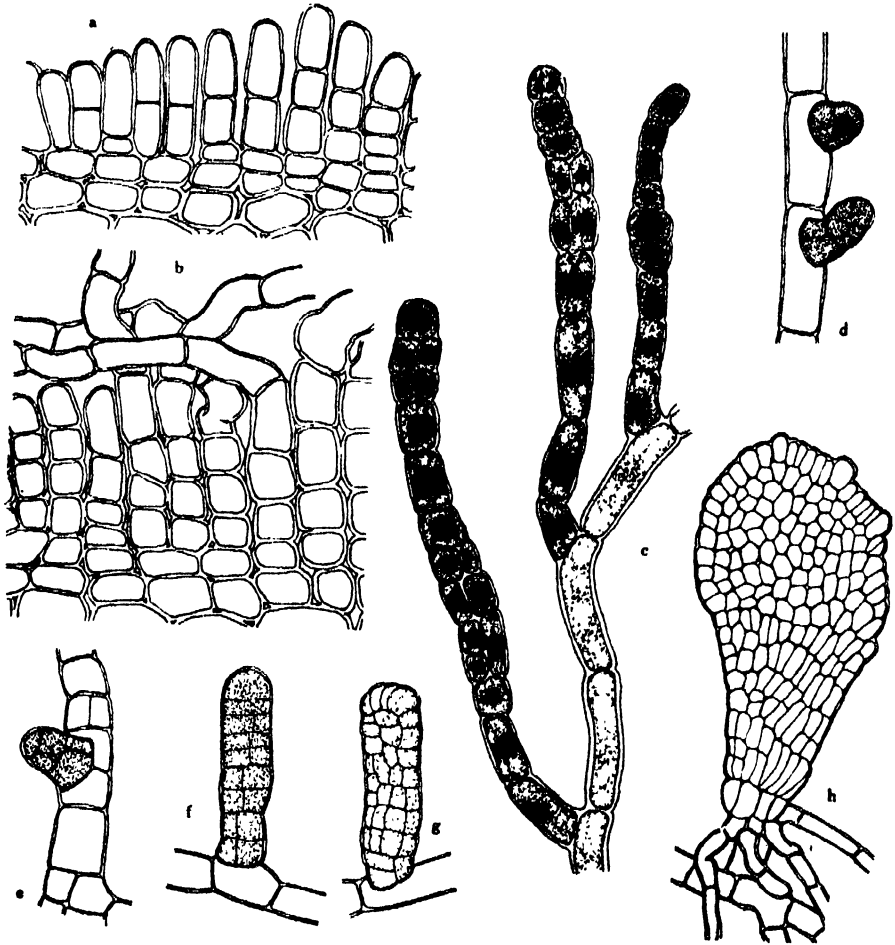
Fig. 1. a, b, Entwicklung des Brutfadens. ×215; c, Drei bandförmige Brutkörper an einem Brutfaden; d–h, Entwicklung des verkehrt eiförmigen Brutkörpers. ×180.

kleine, papillenartige Vorwölbung an den einzelnen Zellen des Brutfadens (Fig. 1, d) und wachsen durch Längs- und Querteilung heran (Fig. 1, e–g). Am oberen Rande dieses Gebildes reihen sich eine Anzahl der Initialzellen. Am basalen, aus zylindrischen Zellen bestehenden Teile dieses Brutkörpers entspringen später zahlreiche Rhizoiden (Fig. 1, h).

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* Strenggenommen können sie also nicht Brutkörper genannt werden.

Es ist eine merkwürdige Tatsache, dass an diesen zwei Arten Brut-körpern inzwischen reichlich Tetrasporängien gebildet werden. Bei den bandförmigen Brutkörpern entstehen Tetraspoangien immer seitlich (Fig. 2, a). Sie sind gestielt oder ungestielt (Fig. 2, b, c). Bei den verkehrt eiförmigen Brutkörpern werden Tetrasporangien meistens auch seitlich, aber selten auf der Flächenseite gebildet (Fig. 2, d). Fast immer setzen sie sich direkt an den Brutkörper (Fig. 2, e, g). Nur sehr selten sehen wir aber die an den aus dem basalen Teile des Körpers entspringenden Rhizoi-den gipfelständig gebildeten Sporangien (Fig. 2, d). Bei solchen scheinbar gestielten Sporangien sind die direkt unter dem Sporangium liegenden, einigen quergestreckten, dünnwandigen Zellen plasmareich (Fig. 2, f).
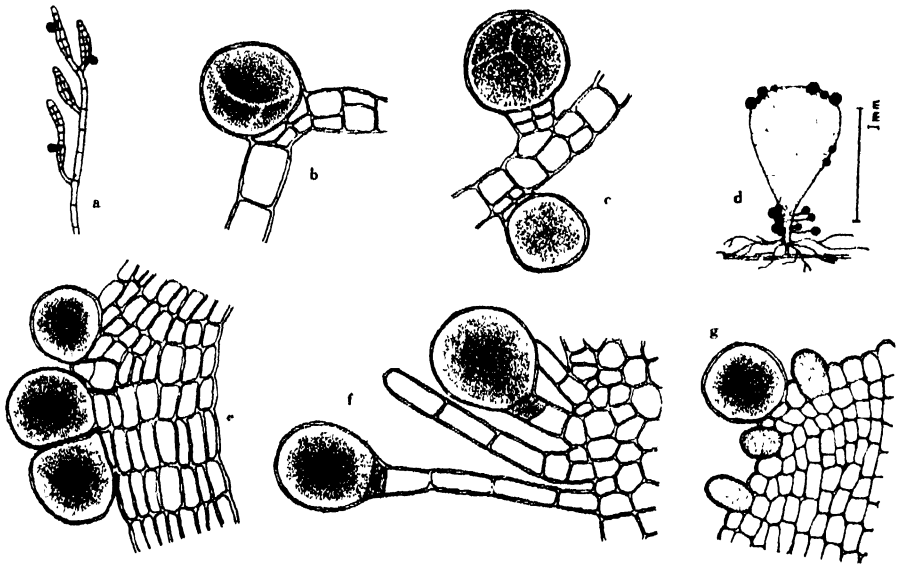
Fig. 2. Tetrasporangien an den Brutkörpern. a, Schematische Darstellung der bandartigen Brutkörper mit Tetrasporangien; b-c, Tetrasporangien an den bandartigen Brutkörpern. ×180; d, Schematische Darstellung des verkehrt eiförmigen Brutkörpers mit Tetrasporangien; e, f, g, Tetrasporangien am verkehrt eiförmigen Brutkörper. ×180.

Unter Phaeophyceen ist Brutkörperbildung schon vielmals bei Sphace-lariaceen mitgeteilt worden. Unter Dictyotaceen ist sie von WILLIAMS[1] bei *Dictyota*, von OKAMURA[2] bei *Zonaria* beschrieben. *Spathoglossum*

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[1] WILLIAMS, J. L. Studies in the Dictyotaceae. 1. The Cytology of the Tetrasporangium and Germinating Tetraspore. Ann. Bot., Vol. 18, (1904) p. 142.

[2] OKAMURA, K. Sôrui Keitogaku (1928), p. 179, fig. 250.

gehört auch zu dieser Familie. Also wahrscheinlich kommt die Brut-körperbildung bei dieser Familie ziemlich oft vor.

THE DIURNAL RHYTHM OF TEMPERATURE IN THE MOUND OF AN ANT, *FORMICA TRUNCORUM TRUNCORUM* VAR. *YESSENSIS* FOREL, WIDELY DISTRIBUTED AT MT. HAKKÔDA[1]

(DIURNAL RHYTHM OF ACTIVITIES IN INSECTS AND ITS ENVIRONMENTAL CONDITIONS NO. VII)

By

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Biological Institute, Tôhoku Imperial University, Sendai

(With 7 figures

Received January 21, 1939)

INTRODUCTION

It scarcely needs mention that the observation of the ecoclimate is, in the field of ecology, very important in order to know the essential conditions of insect activity. Furthermore, it is desirable to investigate the micro-climate, since the general environmental condition of the habitat is often remarkably different from the micro-environmental condition to which the insect has yielded.

The micro-climate in the nest of an insect, forming a social life, is remarkably different from the outer meteorological conditions. It seems to be very clear that this characteristic climate is not produced by the regulation of individual body temperature. It is due not only to the physical condition of the nest, but also to the so-called social temperature regulation. Some very elaborate investigations concerning the temperature regulation occurring in nests of some *Hymenoptera* were dealt with recently by HIMMER (1927) and by STEINER (1929, 1930).

A mound-building ant, *Formica truncorum truncorum* var. *yessensis* FOREL[2], is widely distributed on the plateau in the central and northern parts of Japan, forming its mound with pine-needles or similar materials. But investigations on the ant-mounds, especially those concerning the said temperature regulation occurring in the interior of the mound have not hitherto been conducted in Japan.

On Kayano-hara at Mt. Hakkôda, a great number of mounds of the said mound-building ant are seen, and are a special sight on this plateau, which has a simplified flora caused by pasturage (Fig. 1 a). The frequency distribution of the mounds is pretty large (Fig. 2). Each of these mounds consists of heaps of withered lawn grass, pieces of leaf-stalks or of twigs piled up on bases of living trees or of stumps (Fig. 1 b).

a

b

c
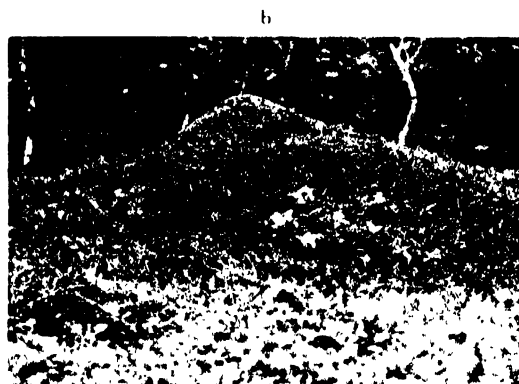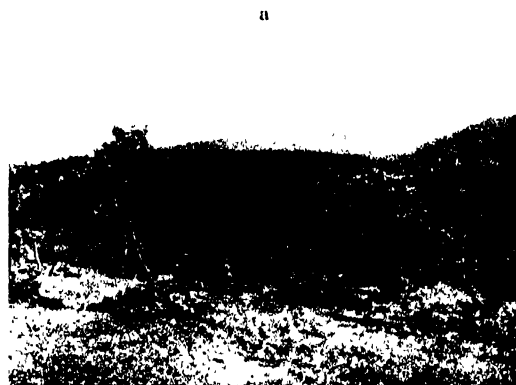
Fig. 1. a, General view of Kayano-hara at Mt. Hakkôda; b, One of the largest ant-mounds; c, Showing the fence which was made around the ant-mound.

I have measured the diurnal rhythm of temperature occurring in the interior of the said ant-mound and have investigated the temperature regulation during the summers of both 1936 and 1938. In the following paragraph I should like to deal with the results thus obtained.

Botanical Laboratory, who gave me a great deal of assistance without which it would have been difficult for me to carry out the present investigation. I am also indebted in many ways to all the other members of the same laboratory.
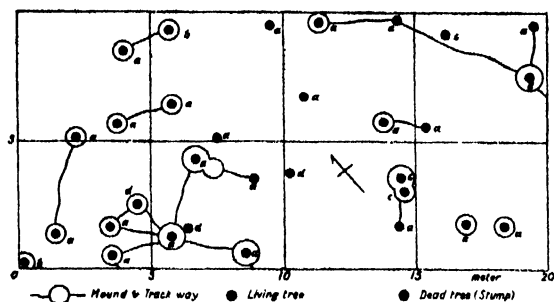
Fig. 2. A map showing the frequency distribution of the ant-mounds. a, *Quercus crispula* BLUME; b, *Rhus tricocarpa* MIQ.; c, *Tilia japonica* SIMK.; d, *Salix Reinii* FRANCH. et SAV.

MATERIAL AND METHOD

One of the largest mounds situated in the southern part of Kayano-hara was selected for the experiment, and a fence was made around it to prevent damage which might have happen by the intrusion of oxen or horses in the pasturage (Fig. 1 c).

A black bulb thermometer was used to measure the solar radiant energy. The air temperature was measured at the height of about 20 cm above the ground using an ASMAN's respiratory psychrometer. The micro-temperature was measured in the following four places located in the interior of the mound, i. e., two places located 5 cm below the surface near the summit, one of which, situated close to the slope faced toward the north-east, while the other also situated close to the slope faced toward the south-west; a place located 10 cm below the summit of the mound, and then another place of 20 cm depth below the summit. As a control experiment an artificial mound was prepared near the said ant mound, constructed of the same material as that seen in the case of the natural ant-mound, and the micro-temperature was also measured in this mound in the same manner as above described.

Experiments were made during the time extending from the night of the 13th of August, 1938, until 1 p.m. of the 15th of the same month, and also from the afternoon of the 18th until the afternoon of the 20th of August.

Thus, the diurnal rhythm of the mound temperature was measured, and also the temperature regulation was observed throughout the summer in the case of the mound-building ant above mentioned.

TABLE 1

Experimental Results Obtained in the Present Investigation

Time (hour)	Air temp.	Humidity	Black bulb	5 cm depth				10 cm mound	15 cm control	20 cm mound	Remarks
				north-west		south-west					
				mound	control	mound	control				
13/VIII											
17	27.3	—	—	27.0	36.7	43.4	43.0	32.4	35.0	28.4	
18	25.9	—	—	25.5	33.7	38.8	38.9	32.0	32.3	28.3	
19	23.9	—	—	24.5	32.4	37.0	35.6	31.3	30.5	28.3	
14/VIII											
4	18.1	—	17.4	22.5	22.4	23.7	22.6	26.3	23.8	27.2	dewy
5	18.1	—	18.2	23.0	22.9	23.8	23.4	26.0	23.8	27.2	sunrise; bright
6	22.0	—	29.4	26.5	26.5	25.6	25.0	26.0	25.5	27.0	bright
7	26.0	—	48.6	32.5	30.8	28.4	29.1	27.0	27.2	27.1	"
8	27.1	—	42.4	37.5	37.2	30.2	31.6	27.3	29.0	27.0	"
9	27.0	—	38.7	35.5	35.5	31.0	32.1	27.8	29.0	27.0	cloudy (*Stratus, Strato-cumulus*)
10	25.3	—	31.8	34.0	34.7	31.2	32.6	27.8	28.5	26.9	"
11	25.0	—	27.5	31.5	32.7	30.4	31.4	28.0	27.8	27.0	drizzle
12	24.7	—	25.9	29.6	31.2	29.6	30.7	28.3	27.5	27.1	"
13	24.5	—	29.9	29.0	30.0	29.0	30.5	28.0	27.0	27.2	"
14	26.0	—	33.5	30.6	32.8	30.7	29.6	28.7	28.2	27.2	soft sunbeam
15	26.7	—	35.6	30.4	32.7	31.1	29.0	28.5	28.7	27.3	"
16	24.4	—	26.4	28.1	29.8	29.3	28.1	28.3	27.5	27.3	"
17	23.9	—	23.3	27.0	27.6	27.6	26.1	28.2	26.6	27.4	cloudy (*Stratus, Strato-cumulus*)
18	22.7	—	22.0	26.1	25.7	26.7	24.9	27.7	25.8	27.5	"
19	22.6	—	21.2	25.2	24.6	26.1	23.7	27.4	25.6	27.5	"
15/VIII											
4	18.9	—	17.7	21.7	18.8	21.7	19.3	24.6	22.0	26.5	cloudy (*Strato-cumulus, Nimbostratus*)
5	19.3	—	18.2	21.7	19.4	21.7	19.6	24.6	21.9	26.4	"
6	20.8	—	22.3	22.7	20.6	22.4	20.8	24.6	22.5	26.3	"
7	21.8	—	23.8	23.8	22.8	23.8	22.8	24.9	23.0	26.2	"
8	22.7	—	27.4	25.0	24.0	24.8	23.6	25.2	23.6	26.2	"
9	25.0	—	39.8	27.5	26.9	26.3	25.9	25.5	24.8	26.2	soft sunbeam
10	26.9	—	42.4	25.5	28.9	28.5	28.2	25.6	25.6	26.2	windy (moderate wind)
11	24.8	—	29.3	24.6	25.7	27.1	26.4	26.4	25.6	26.1	"
12	26.7	—	37.3	27.5	28.2	28.0	27.5	26.6	26.0	26.2	windy (strong wind)
13	26.1	—	37.1	24.0	26.6	28.1	27.5	26.6	26.0	26.2	"

Time											Weather
18/VIII											
15	32.6	71	57.3	35.8	40.0	39.3	40.1	30.9	33.2	28.2	cloudy (*Cumulus*)
16	27.4	85	31.8	34.1	38.2	38.1	38.4	30.5	30.8	28.3	,, (*Cumulonimbus*)
17	27.6	85	34.2	33.5	35.1	35.6	35.0	30.5	29.4	28.6	16.35: shower; 16.40: sunshine
18	26.3	85	28.4	32.0	32.2	33.8	33.6	30.8	28.8	28.7	,,
19	23.5	89	22.7	30.6	30.0	31.3	30.8	30.6	27.3	28.8	,,
19/VIII											
4	25.2	87	23.3	26.2	25.8	25.4	26.0	26.0	25.0	27.0	windy all the day long (strong wind)
5	24.2	87	23.2	25.6	25.6	24.8	25.6	25.9	25.0	26.9	cloudy (*Alto-cumulus, Strato-cumulus*)
6	25.1	83	26.4	25.5	25.6	25.2	25.5	25.9	24.7	26.8	,,
7	25.4	82	28.8	26.0	26.4	26.2	26.4	26.0	25.2	26.7	,,
8	26.6	79	33.6	26.3	27.0	26.7	27.3	26.0	25.8	26.5	,,
9	27.4	78	37.7	26.5	27.8	26.8	27.8	26.0	26.2	26.4	,,
10	27.8	75	40.3	26.8	28.6	27.6	28.3	26.2	26.7	27.3	,,
11	28.4	75	44.1	27.2	29.5	28.4	28.8	26.6	27.2	26.3	clear (*Cumulus*)
12	30.9	71	61.8	29.4	31.5	31.2	31.5	27.3	28.6	26.5	,,
13	33.4	65	64.8	29.7	33.0	31.7	34.0	28.2	29.8	26.5	,,
14	31.4	67	60.6	29.7	33.8	35.2	35.3	28.8	30.2	26.8	,,
15	31.1	70	51.8	29.8	33.4	33.8	36.1	29.2	30.2	27.1	,,
16	29.2	70	37.8	29.2	31.7	32.9	33.1	28.0	29.0	27.2	,,
17	27.2	71	29.9	28.7	30.0	30.4	31.6	27.5	27.8	27.2	,,
18	25.7	78	26.8	27.5	28.7	28.6	30.0	27.6	27.2	27.2	
19	24.5	81	23.3	27.0	27.9	27.8	28.4	27.2	26.3	27.2	
20/VIII											
4	22.0	97	20.8	24.5	23.4	25.2	23.6	25.1	23.7	26.1	dense fog
5	21.9	97	20.8	24.6	23.4	24.7	23.6	25.2	23.6	26.1	,,
6	22.1	94	23.3	24.7	23.9	25.2	24.2	25.2	23.8	26.1	cloudy (*Stratus*)
7	23.2	94	26.2	25.6	25.4	26.2	25.8	25.8	24.5	26.1	,,
8	25.2	89	36.2	27.4	29.2	28.4	28.8	26.5	25.8	26.2	,,
9	26.6	84	39.2	28.2	30.4	28.7	30.0	27.1	26.8	26.2	
10	26.2	84	42.8	29.0	31.4	29.8	31.4	27.1	27.5	26.3	
11	22.2	88	25.4	28.5	29.8	29.2	29.8	27.0	26.5	26.4	shower

RESULTS AND DISCUSSION

I. Micro-climate in the Ant Mound

Results obtained in the present experiments are tabulated in Table 1 and shown in Fig. 3 a, b.
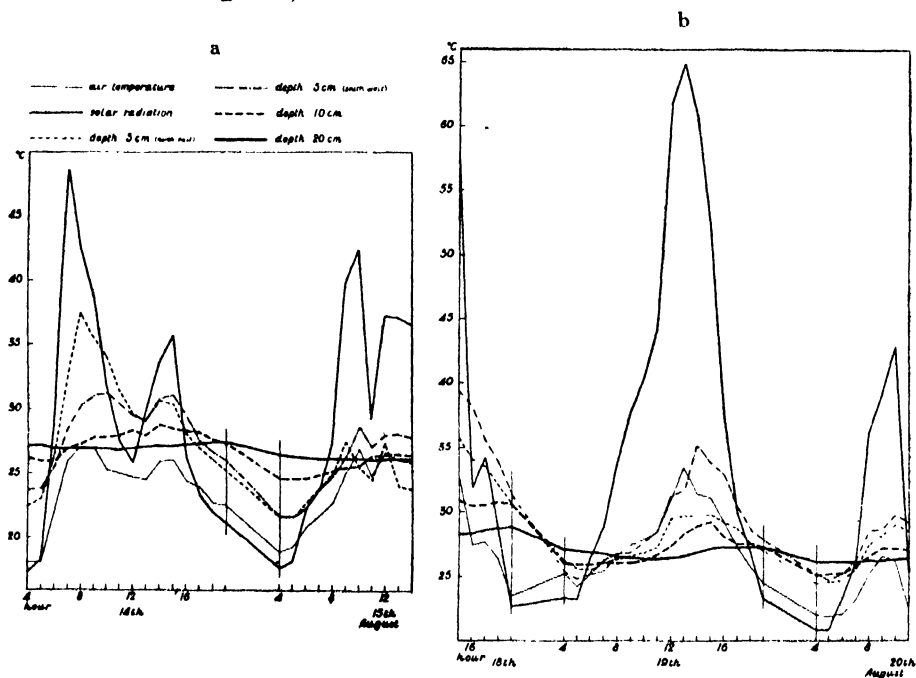
Fig. 3 a, b. Diurnal rhythm of temperature in the ant-mound and those of the environmental meteorological factors.

ᵗ   According to these data, the mound temperature seems to receive little direct influence from the change in the external air temperature, but rather is affected directly by the fluctuation of the solar radiation. This fact may be distinctly observed when we compare Fig. 3 a with Fig. 3 b. Namely the mound temperature is almost equal in both cases as is seen in the above figures, though the air temperature on the 14th of August was about 6°C lower than that on the 19th of the same month.

Then, the direct influence of the diurnal rhythm of external temperature factors, especially that of the solar radiant energy, which may be looked upon as the heat-source of the mound, is inhibited in proportion to its depth below the mound surface (Fig. 3 a, b). That is to say, the temperature measured at a place 20 cm below the summit of the mound

fluctuates only in a small degree ranging from 26.1 to 28.8°C and thus is constant enough to be counted as almost indifferent to the change of external temperature factors, such as the solar radiant energy and the air temperature.

According to HERTER (1923), in the case of *Formica rufa*, which is a form closely related to the present species, the optimum temperature was between 23 and 32°C. Thus the temperature zone, which extends from 26 to 29°C, seems to be very suitable for the activity of this insect.

At a place located 10 cm below the summit of the mound, the temperature diminishes its constancy and fluctuates between 24.6 and 30.9°C, but it may be noted as still fairly constant, the fluctuation being within the range of about 6.3°C, and moreover the temperature above alluded to seems to be suitable for the development of the eggs and the larvae of this ant. But this constancy in temperature can scarcely be observed in the shallow parts below the surface of mound, i. e. the temperature measured at a place located 5 cm below the surface of the mound changes between 21.7 and 35.2°C, and the fluctuation extends over about 15°C. It seems that the diurnal rhythm of temperature in this place of the mound is closely related to that of the solar radiation. It may

Fig. 4. Diurnal rhythm of temperature in the mound and of air temperature.

be caused by the fact that the surface and the shallow places in the mound absorb heat directly from the solar radiation in the daytime, but this same heat is diffused in the air by radiation and by convection during the night. This relation is especially remarkable on the surface of the mound as is shown in Fig. 4.

It is very interesting to note that, in the shallow places of the mound, the temperature rhythm observed in one place may differ remarkably from the temperature of other places. In the present investigation the temperature was measured at two places both located 5 cm below the surface near the summit. One of those two places was situated close to the

slope facing toward the north-east, while the other was situated close to
the same facing toward the south-west. In these two places the courses
of the diurnal rhythm differed distinctly from each other (Fig. 3 a, b).
This fact is clearly due to the relation existing between the direction of
the solar radiation and the inclination of the mound surface. During the
morning of the 14th of August the strong solar radiation affected more
strongly the slope facing toward the north-east than that facing toward
the south-west of the mound, but at 3 p.m. the temperature measured
below the slope facing toward the south-west was higher than that
measured below the slope facing toward the north-east (Fig. 3 a). On
the 19th of August, the weather was. cloudy in the morning, but became
fine from about noon on and the strong solar radiation was measured,
and its influence was seen to be remarkable inside the south-west slope
and thus the temperature was fairly higher than that inside the north-
east slope (Fig. 3 b). This fact, however, was never observed during the
night when no solar radiation was observed, and consequently the tem-
perature in both places in the mound fell to a similar level.

Now, it may be permissible to conclude from the facts learned above
that (1) the diurnal rhythm of temperature found in an ant-mound is
remarkably different from that of its environment, and that (2) the passable
constancy in temperature is observed in such places as those located deeper
than 10 cm from the surface of mound, showing the fluctuation of only
6°C or less, and also that (3) the temperature measured in such places
lies between 24 and 30.9°C, and is suitable for the development of the
eggs, the larvae and pupae of the ant above alluded to.

II. Temperature Regulation in the Ant-mound

We have learned from the above mentioned experiment that there
exists a diurnal rhythm of micro-temperature in the interior of the ant-
mound. Now, the physical and biological temperature regulations occur-
ring in the interior of the mound will be demonstrated in this paragraph
in comparing the said micro-climate with that obtained in the control
experiment. The control experiment was executed using an artificial·
mound which was made of the same material as that used in the case
of the natural ant-mound. The experimental results thus obtained are
tabulated in Table 1 and are shown in Figs. 5 a, b and 6 a, b. Comparing
the diurnal rhythm of the temperature observed at a place located 5 cm
below the surface in the artificial mound with that of the natural ant-

mound, we know that the temperature in the former is always higher in the daytime, but on the contrary is lower during the night than that of the latter. That is to say, the daily fluctuation of temperature shown in the case of an artificial mound is greater than that shown in the case of the natural ant-mound, i. e. it seems that the heat-gain and heat-loss are
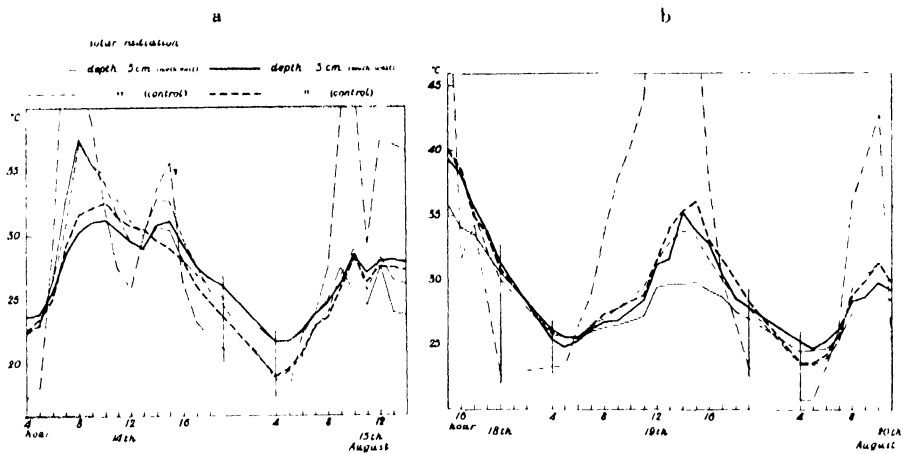
Fig. 5 a, b. Diurnal rhythm of temperature in the ant-mound and that in the artificial mound.

both remarkable in the case of an artificial mound (Fig 5 a, b). The same relation was also observed in other places deeper than 5 cm. When we compare the diurnal rhythm of temperature observed at a place 15 cm deep in an artificial mound with that obtained at a place of 10 cm depth in an ant-mound, a remarkable fluctuation of temperature is noticed in the case of the artificial mound, namely the temperature is higher during the daytime than that in the natural ant-mound, but is lower during the night (Fig. 6 a, b).
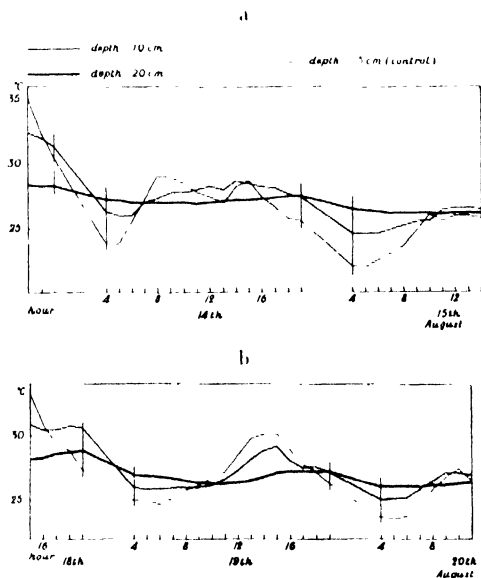
Fig 6 a, b. Diurnal rhythm of temperature in the ant-mound and that in the artificial mound.

Thus it may be concluded that the heat-gain and heat-loss are both more remarkable in an artificial mound than in an ant-mound, and that constancy in temperature is never seen in the case of the artificial mound. Then, too, it seems that the mode of the heat-gain and heat-loss in an ant-mound is distinctly different from that in an artificial mound, and thus it may be suggested that there exists some special mechanism to regulate the temperature in the case of the ant-mound.

Now, we should like to study the mechanism of the heat-gain and heat-loss which takes place in the natural ant-mound. The inner structure of the mound is very rough and is rather porous, but there exist a number of fairly large flat cells connected with each other by means of many galleries running parallel and horizontally in most cases but vertically in other cases (Fig. 7). In these cells the eggs, larvae and pupae are preserved. Thus, it may be said that the ant-mound is, as a whole, in the form of an airy mass, and this structure distinguishes the real ant-mound and is never met with in an artificial mound. Now it seems fairly reasonable to conclude that the constancy in temperature shown in the case of an ant-mound may be due mainly to the structure of the mound above alluded to. That is to say, the rapid heat-gain and heat-loss which may occur in the mound will be inhibited by the existence of the air which fills up the interior of the mound, and thus the constancy in temperature is caused.

Fig. 7. Showing the inner structure of two ant-mounds.

A special habit, which had been already noted in the case of a mound-building ant, *Formica rufa*, by STEINER, was also observed at this

time. It is the habit followed by ants of opening and closing the orifices of the mound. When day is declining, many ants begin to carry withered lawn grass, pieces of leaf-stalks and other things of that kind to their mound and with this material they cover the surface of the mound. Thus they close the openings made in the daytime for exit and entrance, and also repair the broken parts of the mound. Again it is conceivable that this habit of the mound-building ant plays a part in maintaining the constancy in the temperature of the mound and is specially effective in inhibiting the heat-loss from the mound during the night.

STEINER (1930) classified the modes of heat-gain and heat-loss taking place in the social *Hymenoptera* into the two following types.

  I. The physiological heat production is settled for the heat-keeping of the social life.
 II. The physical heat-source is clearly noticed for the heat-keeping of the social life.
      (1) During the active period of this insect, the mound-temperature is higher than the environmental temperature, but is not perfectly constant fluctuating in accord with the change of the environmental temperature. During the resting period of the insect the environmental temperature influences exactly the mound temperature.
      (2) During the active period, the mound temperature is temporarily higher than the environmental temperature, but the physiological heat-production is not established.

According to this classification the mound which was dealt with in the present investigation seemed to belong to the (1) of II-type, but it was evident that the heat-production was very slight in this case. Furthermore STEINER divides the category of the same type into the two following forms, i. e.,

  (a) The physiological heat-production is dominant for the heat-keeping of the mound.
  (b) The physical heat-source is dominant for the heat-keeping of the same.

Formica trumcorum trumcorum var. *yessensis* FOREL clearly belongs to the latter type (b).

Conclusively it seems that the biological temperature regulation in the case of the said ant is very weak and the physical temperature regulation is dominant, and thus heat-keeping of the mound is mainly due to the physical heat-source, especially to that of the solar radiant energy.

SUMMARY

I. In the present paper the results of experiments carried on at Mt. Hakkôda concerning the micro-climate, especially the micro-temperature, in the mound of an ant, *Formica truncorum truncorum* var. *yessensis* FOREL, are dealt with.

II. The diurnal rhythm of the temperature occurring in the interior of the mound is remarkably different from that of the environmental temperature factors. At a place 10 cm or more below the mound surface, the constacy in temperature is clearly seen and it is also noted that the direct influence given by the environmental temperature factors is remarkably reduced. But at those places located in the shallow part of the mound the diurnal rhythm of temperature is greatly influenced by the outer environmental temperature factors, especially by the solar radiant energy, and thus the daily fluctuation of temperature in those place is greater than that of the air temperature.

III. In comparing the diurnal fluctuation of temperature in a natural ant-mound with that in an artificial mound, we know that there exist two modes of temperature regulations in the case of the ant-mound and moreover that the ant-mound is suitable to inhibit the rapid and remarkable heat-gain and heat-loss. We learn that the mound is considered from the physical view point to be, as a whole, an airy mass, and also we know that this kind of ant has biologically a special habit of opening and closing the surface of the mound. But it was noticed that the temperature regulation to be caused physically is dominant for the heat-keeping in the case of this ant, and that the temperature regulation to be executed biologically is very weak.

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POLYCLADS IN ONAGAWA AND VICINITY

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The polyclads serving as the basis of the present report were chiefly collected in 1935–37 by the authorities of the Onagawa Oceano-chemical Institute of the Tôhoku Imperial University from Onagawa Bay and its vicinity. Some specimens were obtained by myself during my short stay at Onagawa in June, 1938.

The material belonged to the 12 species listed below, of which 5 appear to be new to science.

ACOTYLEA

Family Plehniidae

1. *Plehnia pacifica* sp. nov.

Family Leptoplanidae

2. *Notoplana libera* sp. nov.
3. *Notoplana sophia* sp. nov.
4. *Notoplana humilis* (STIMPSON)
5. *Notoplana koreana* KATO

Family Diplosolenidae

6. *Pseudostylochus nationalis* sp. nov.
7. *Pseudostylochus obscurus* (STIMPSON)
8. *Pseudostylochus takeshitai* YERI et KABURAKI
9. *Pseudostylochus aino* KATO
10. *Pseudostylochus edurus* KATO

COTYLEA

Family Pseudoceridae

11. *Pseudoceros sagamianus* KATO

Family Prosthiostomidae

12. *Prosthiostomum bellum* sp. nov.

Before proceeding further I should like to express my hearty thanks to the gentlemen of the Institute for their kindness in placing the valuable collection at my disposal. My most sincere thanks must also be extended to Dr. T. IMAI for the courtesy shown me during my stay at Onagawa.

1. Plehnia pacifica sp. nov.

(Pl. III, Figs. 1-4; Text-figs. 1-3)[1]

The collection contains a single Craspedommatous polyclad referable to the genus *Plehnia*, which was brought up by the dredger on July 19, 1935 from a depth of 28 m off the west coast of Tako-sima near Onagawa.

It is a new species and is named *Plehnia pacifica*.

In the preserved state, the body is firm and thick, of an oval form, being slightly broader posteriorly, and measures 20 mm long by 9 mm broad. The colour of the body in alcohol is uniformly light brown. No tentacles are observed. Though the eye-spots are very small and embedded deeply in the parenchyma, they are plainly recognizable in the clarified specimen; while in *Plehnia japonica* (BOCK, 1923) the existence of eyes was only determined after examining the sections. A small brain is situated at the posterior limit of the first seventh of the body and over the brain region a small number of ocelli are arranged in two elongated groups.
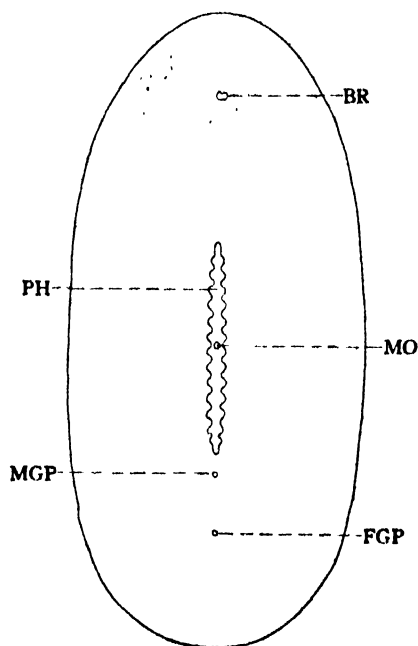
A little behind the level of the brain lie a pair of tentacular groups of eyes, each of which is represented by only two rather large ocelli. Along the margin of the anterior half-body there are numerous irregularly arranged eye-spots. Frontal eyes are

Fig. 1. *Plehnia pacifica.* ×7.

also present, but are very few in number. The marginal and frontal ocelli are sparsely pigmented.

The epidermis is slightly higher on the dorsal than on the ventral side and contains an abundance of minute eosinophilous secretion granules and a small number of rhabdites. The dermal musculature is well-developed as in *P. japonica*. The mouth is placed nearly in the middle part of the body, and leads into the pharyngeal chamber, which holds a plicated pharynx occupying almost the middle third of the body.

A pair of seminal canals run forward from the hind part of the body and turn posteriorly at the level of the mouth, and near the rear end of the pharyngeal chamber each passes into a large, elongated false seminal vesicle with a thick muscular wall. The ducts from these seminal vesicles proceed

Fig. 2. *Plehnia pacifica*; arrangement of tentacular and cerebral eyes. ×30.

antero-medially to unite into a single duct, which immediately opens from the ventral side to the distal narrow part of the prostate vesicle. Lying directly behind the pharyngeal chamber, the prostate vesicle consists of many saccular glands, and tapers postero-ventrally to open at the tip of a large conical penis. The muscular wall of the prostate vesicle is exceedingly developed antero-dorsally, and is composed chiefly of circular muscle fibers and of outermost thick fibres, which are more loosely arranged, consisting a special cap for the proximal portion of the vesicle. Numerous ductules penetrate this musculature to open into the vesicle. The penis forms the entire frontal wall of the antrum, which opens outside directly behind the posterior end of the pharyngeal chamber. The antrum is filled with a special cyanophilous secretion. In *japonica* the secretion originated from the external epithelium of the penis as well as from the glands found on its ventral wall, while, in the present species, the cyanophilous substances are secreted from a large number of subepithelial glands embedded in the parenchyma close to the dorsal and ventral musculatures at a long distance from the penis.

Slightly posterior to the male genital pore lies the female aperture, which leads upwards into a large true vagina bulbosa, round which is developed a thick connective tissue layer, as in *Cryptocelis loveni* (Bock, 1913,

p. 107). The upper end of the vagina bulbosa passes into a narrow duct, which soon expands anteriorly into a long, wide shell gland duct. The
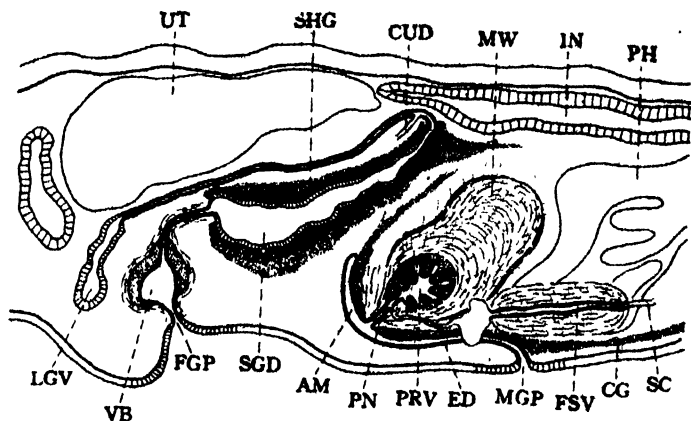
Fig. 3. *Plehnia pacifica;* sagittal section through genital organs. ×22.

latter duct receives a common uterine duct in the dorsal part of the body, and continues to the narrow, long duct of Lang's glandular vesicle. Lang's vesicle is small and irregularly elongated, disposed immediately behind the vagina bulbosa in the ventral part of the body. In the uterus there are found a mass of spermatozoa as well as a large number of eggs, as pointed out by BOCK in the case of *japonica*.

Under the genus *Plehnia* have been recorded two species, *arctica* and the *japonica* mentioned above. The former species is an arctic form and entirely lacks the eyes. The latter species was described by BOCK, his account being based on two individuals found at a depth of 12–15 m in Kôbe Bay. The present worm is closely related to *japonica*, but is easily distinguished from it by the possession of the well-developed vagina bulbosa and the structure and position of Lang's glandular vesicle, viz. in *japonica* the vesicle is dorsally situated and its duct is very short.

2.   Notoplana libera sp. nov.

(Pl. IV, Figs. 3, 4; Text-figs. 4–6)

Two specimens of this new species were collected at Takenoura on August 14, 1935.

The body is elongated with a round anterior end and a bluntly pointed posterior extremity. It measures about 20 mm in length and 5 mm in

breadth at the brain region. The colouration appears to be a uniformly brown or milky white with no markings.

Tentacles are totally lacking. The tentacular groups of eyes lie at the hind border of the first quarter of the body, consisting of a small number of rather large ocelli. Cerebral eyes are chiefly arranged on either side of the anterior part of the brain, and some of them are scattered irregularly behind the level of the tentacular groups. The mouth is situated almost in the middle of the body, and leads into the pharyngeal chamber at the anterior end of the last third of its length. The pharynx is normally plicated.

The genital pores are in rather close proximity to each other, lying near the anterior limit of the last third of the body. Numerous immature testes are found in the ventral half of the body, distributed thickly below the intestinal branches. The ovaries are also not yet fully developed. Occurring directly behind the posterior termination of the pharyngeal chamber, the seminal vesicle is a tubular organ surrounded by a thick muscular wall, and receives from a postero-ventral direction a common duct formed by the union of two seminal canals. Arising from the dorsal end of the seminal vesicle the ejaculatory duct immediately pierces the prostate vesicle to run postero-ventrally, and opens at the tip of a very small penis into a narrow elongated antrum masculinum. The prostate vesicle, which is dorsally situated, is pyriform in shape, coated with a thick muscular wall and consists of a few saccular glands which open to the ejaculatory duct at their distal ends. The penis is extremely small and lacks a stylet.

Fig. 4. *Notoplana libera.* ×3.

Fig. 5. *Notoplana libera*; arrangement of eyes. ×35.

Close behind the male genital pore is situated the female aperture, which leads antero-dorsally through the narrow antrum into the shell gland duct encircled by muscle fibers. Near the dorsal surface the latter duct turns rearwards and receiving a common uterine duct from

ventrad continues to the moniliform duct from Lang's large glandular vesicle which is of an elongated shape. The shell gland secretion is not yet formed.
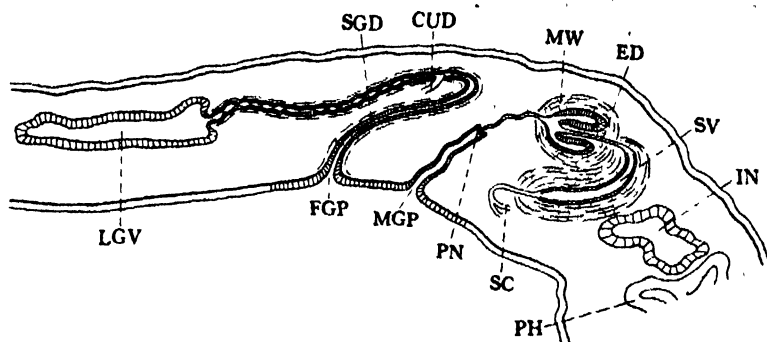
Fig. 6. *Notoplana libera;* sagittal section through genital organs. ×35.

This species resembles *Notoplana septentrionalis* (KATO, 1937 c) in the general features of the genital organs, but differs from it in the absence of tentacles, in the small size of the penis and in the hinder position of Lang's vesicle.

3. Notoplana sophia sp. nov.
(Pl. III, Fig. 5; Pl. IV, Fig. 5; Text-figs. 7-9)

This new species is represented by two examples which were found on the wooden floats of a gill-net at Konorihama on Nov. 25, 1936.

The body is of the common *Notoplana*-type, measuring 20–25 mm long and 7–8 mm at the widest part. The colour of the body in alcohol is white without markings.

There is no tentacle. The tentacular clusters of eyes are situated at a distance of about a quarter of the body-length from the anterior end, and many cerebral eyes are scattered on either side of the median line, chiefly in front of the tentacular groups. The position of the mouth is near the middle of the body, and leads into the pharyngeal chamber at its centre. The genital openings occur at the anterior limit of the last quarter of the body.

The general plan of the reproductive organs is similar to those in other species of the genus. The seminal vesicle lies laterally to the moderately large prostate vesicle. The penis is flatly conical in shape, and lacks a stylet. Numerous testes are scattered mainly in the ventral

part of the body and the seminal canals are full of sperm, while the ovaries are only in a rudimentary state and the shell gland secretion is not yet formed. The shell gland duct takes the usual curved course, and, after receiving a common uterine duct from ventrad, passes into the duct of Lang's glandular vesicle. The latter duct is distended with a mass of spermatozoa, and assumes a bead-like appearance, which results from the repeated constrictions of powerful sphincter muscles. Lang's
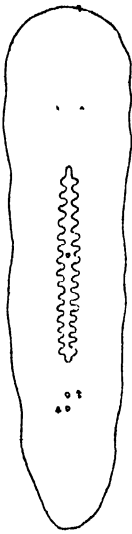
Fig. 7. *Notoplana sophia.* ×3.
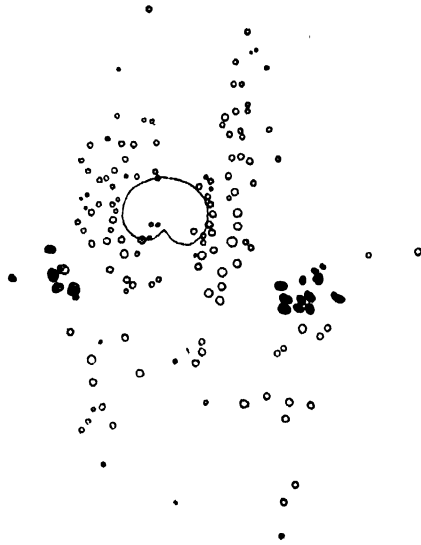
Fig. 8. *Notoplana sophia;* arrangement of eyes. ×28.
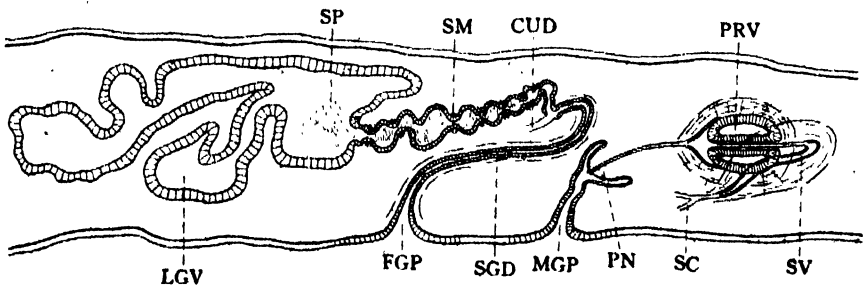
Fig. 9. *Notoplana sophia;* sagittal section through genital organs. ×35.

vesicle is a very large, irregularly folded saccular body, lined with columnar cells bearing coarse secretion granules, and contains a sperm mass in its anterior portion. The exact shape of the vesicle could not be determined from the available specimens owing to their poor state of preservation.

This species is distinguished from any of the known members of the genus by the possession of the flatly conical penis and the irregularly folded Lang's vesicle.

4. Notoplana humilis (STIMPSON)

Leptoplana humilis: STIMPSON, 1857, p. 9.
Notoplana humilis: YERI et KABURAKI, 1918, pp. 11-13.

This species is very common on a sandy beach in the vicinity of the Institute.

5. Notoplana koreana KATO

(Text-fig. 10)

Notoplana koreana: KATO, 1937 b, pp. 234-235.

Two specimens referable to *Notoplana koreana* from Korea were contained in the collection. One specimen obtained from Isihama on July 14, 1935, measures 32 mm long by 6.5 mm broad, and the other one from Mamakohama, on July 31, 1935, is without the posterior half of the body.

The body is elongated with a round anterior and a slightly pointed posterior extremity. The tentacles are not discernible in the preserved state. The arrangement of the cerebral and tentacular eyes is as shown in figure 10. The prostate vesicle is small and rather dorsally disposed. The penis is large and elongated, conical in shape, without a stylet. The antrum masculinum is deep and the shell gland duct is short. Lang's glandular vesicle is spherical and moderately large. The male and female genital pores, a little separated from each other, open outside near the anterior border of the last third of the body. The arrangement of the genital organs is characteristic of the species (*cf.*, KATO, 1937 b, p. 235, Fig. 3).

Fig. 10. *Notoplana koreana;* arrangement of eyes. ×35.

6. Pseudostylochus nationalis sp. nov.

(Pl. IV, Fig. 6; Text-figs. 11–12)

A single specimen· was obtained by myself, together with *Pseudostylochus takeshitai* and *edurus*, at Konorihama on June 25, 1938.

The body in life is of an oval form as in *edurus*, measuring 30 mm long by 20 mm broad. The ground colour of the dorsal surface is a milky white, covered uniformly with brown spots, which are smaller in size than in *takeshitai*, and fainter in colour than in *edurus*. Therefore, in the living state this worm is easily distinguished from the other two species.

Lying near the posterior end of the first fifth of the body, the nuchal tentacles are very small, and each contains numerous ocelli in the interior. The cerebral eyes are scattered, as usual, on either side of the brain. The mouth is situated nearly in the middle

Fig. 11. *Pseudostylochus nationalis;* arrangement of eyes. ×22.

of the body, and leads into the pharyngeal chamber having a plicated pharynx.

Close behind the rear end of the pharyngeal chamber, the seminal canals unite into a median common duct to pass into the seminal vesicle. The latter vesicle is tubular and provided with a muscular wall, situated directly under the prostate vesicle. The ejaculatory duct runs parallel with the lower border of the thick muscular wall of the prostate, and opens into its duct. The shape of the large prostate vesicle is characteristic, as illustrated in figure 12. The penis is large and presumably in life would be conical in shape. The flatly wide antrum masculinum opens into the exterior at its hinder part, a little in front of the anterior limit of the last quarter of the body.

The female genital orifice occurs just behind the male aperture, and the sucking structure is well developed round the gonopore. The shell gland turns posteriorly at the level of the male aperture, and soon continues to the common uterine duct and the duct of Lang's glandular vesicle. The latter vesicle is comparatively small and oblong.

The genus *Pseudostylochus* contains 12 species, of which 6 (*aino,* *edurus, maculatus, meridialis, okudai, stimpsoni*) have the sucking structure
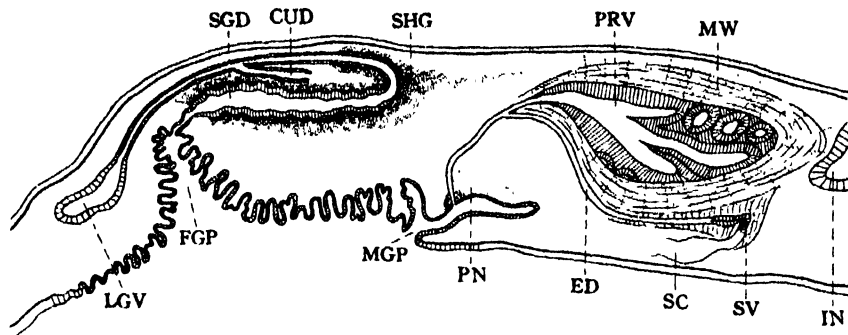
Fig. 12. *Pseudostylochus nationalis*; sagittal section through genital organs. ×22.

mentioned above. Of these 6 species the present planarian is more closely related to *aino* than the others. However, this worm is specifically distinguished from *aino* by the shape of the prostate vesicle and the size and position of the seminal vesicle (*cf.* KATO, 1937 c, p. 130, Fig. 8).

7. Pseudostylochus obscurus (STIMPSON)

Stylochus obscurus: STIMPSON, 1857, p. 11.
Pseudostylochus obscurus: YERI et KABURAKI, 1918, pp. 30-31.

The collection contains several specimens of this species, which were collected at Konorihama and Isihama on July 16, 1935 and on Feb. 19, 1937, respectively. Numerous examples are also obtained by myself under stones between tide-marks on the sandy beach in front of the Institute.

The body is oval in shape, measuring 40 mm by 30 mm in larger individuals. In general, a slight median depression is present at the posterior end of the body, and near this depression lie the genital pores.

This *Pseudostylochus* is widely distributed on the Pacific coasts of Japan, and is easily distinguished from other species of the genus by the hinder position of the genital openings.

8. Pseudostylochus takeshitai YERI et KABURAKI

(Pl. III, Fig. 6; Text-figs. 13-14)

Pseudostylochus takeshitai: YERI et KABURAKI, 1918, pp. 26-28.

Three specimens which agree in every detail with *Pseudostylochus* *takeshitai* from Matuwa near Misaki were collected by myself under

stones at Konorihama on June 25, 1938.

The elongated-oval body is more broadly rounded at the anterior end than at the posterior, measuring 40 mm in length and 20 mm in breadth. The colour of the dorsal surface is milky white with scattered minute light brown spots and darker along the midline. The tentacles are small and bluntly conical in shape, situated at about the hind limit of the first quarter of the body. The disposition of the eyes is shown in figure 13.

The structure and arrangement of the genital organs of this worm are very characteristic, as illustrated in figure 14. The large cylindrical
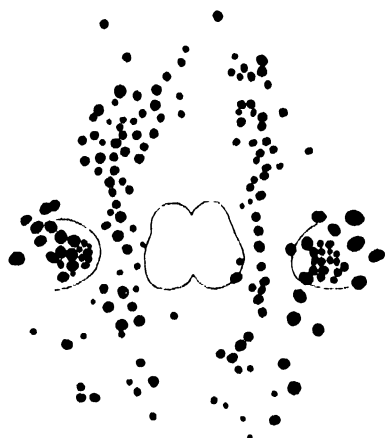
Fig. 13. *Pseudostylochus takeshitai;* arrangement of eyes. ×28.
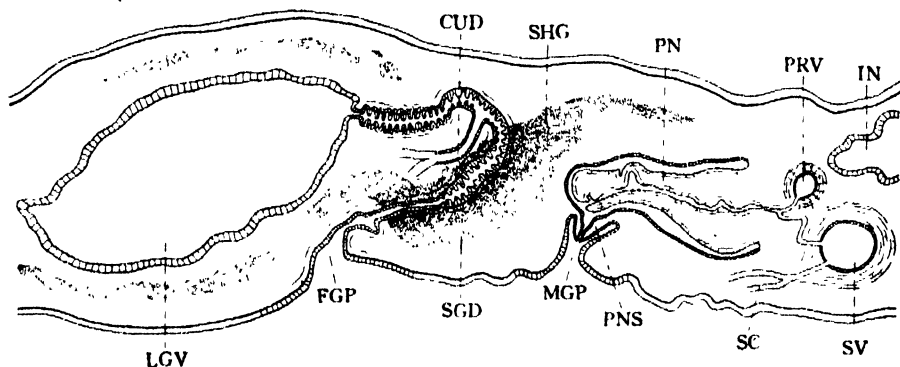
Fig. 14. *Pseudostylochus takeshitai;* sagittal section through genital organs. ×35.

penis is disposed horizontally in the penis sheath and is provided with a special pad of connective tissue on its tip. Lang's glandular vesicle is very large.

9. Pseudostylochus aino KATO

Pseudostylochus aino: KATO, 1937 c, pp. 129-130.

Of the four specimens found in the collection two were dredged from a depth of 8.4 m at Mamakohama (On July 18, 1935), one from a depth

of 18 m at the outlet of Okišhi Bay (On July 20, 1935) and the fourth from Isihama (On July 14, 1935).

The body in the preserved state is oval in shape, the anterior end is more broadly rounded than the posterior. The larger specimen measures 20 mm long by 13 mm broad at the widest part. A pair of small tentacles are situated a little behind the level of the first sixth of the body. The mouth is subcentral, slightly anterior to the middle of the body. The genital pores lie at about the last third of the body length. The colour of the living worm has not yet been recorded. The arrangement of the male reproductive organs are peculiar to the species.

10. Pseudostylochus edurus KATO

Pseudostylochus edurus; KATO, 1938 b, pp. 584-585.

A single specimen, referable to *Pseudostylochus edurus* from Seto, was obtained by myself under a stone at Konorihama on June 25, 1938.

The present worm is much larger than the Seto specimen, measuring 30 mm long by 20 mm broad. The dorsal surface is covered with dark-brown mottles on the light brownish green background, and is darker along the median line. In the Onagawa specimen a large quantity of brown pigment granules is observed in the dorsal dermal musculature. Small tentacles are situated at the posterior border of the first fifth of the body. The mouth is at the hinder end of the second third of the body. The penis is small and conical in form. The large prostate vesicle is of an ovoid shape. The seminal vesicle is moderately large, lying in front of the prostate. Lang's glandular vesicle is large and elongated. The genital pores are at the rear limit of the third fifth of the body.

11. Pseudoceros sagamianus KATO
(Text-figs. 15, 16)

Pseudoceros sagamianus: KATO, 1937 d, pp. 362-363.

In the collection was found a single specimen of *Pseudoceros*, which was obtained on a submerged slate at Konorihama on Oct. 16, 1935.

Although the specimen was severely damaged, closer examination has revealed that the worm is identical with *Pseudoceros sagamianus* from Misaki. The body, measuring about 50 mm long by 20 mm broad, is oval and leaf-like with a frilled margin and a somewhat pointed posterior extremity. The marginal tentacles are represented by folded flaps of the

anterior margin. The colour has entirely faded away. The arrangement of eye-spots is, as shown in figure 15, characteristic of the species. The prostate vesicle is small and oblong. The seminal vesicle is large and receives separately a pair of seminal canals. From the features mentioned above
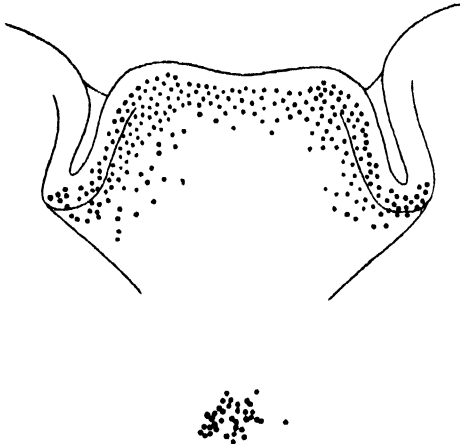
Fig. 15. *Pseudoceros sagamianus;* arrangement of eyes. ×22.
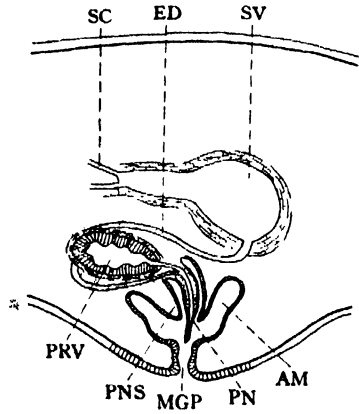
Fig. 16 *Pseudoceros sagamianus;* sagittal section through genital organs. ×22.

this planarian is easily distinguished from the allied species *P. exoptatus* (KATO, 1938 b) which was found in great numbers on submerged panels at Seto, Wakayama Prefecture.

12. Prosthiostomum bellum sp. nov.

(Pl. IV, Figs. 1, 2; Text-figs. 17, 18)

This new species is based on three individuals collected at Mamako-hama on July 31, 1935.

The preserved specimen is elongated in shape with bluntly pointed anterior and posterior ends, measuring 15 mm long by 4 mm broad. The frontal margin of the body is a little depressed in the middle part. The ground colour of the dorsal surface is milky white, over which are
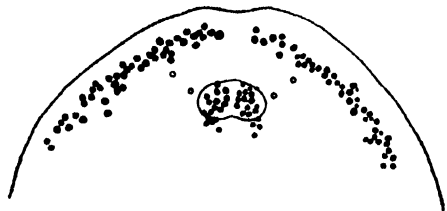
Fig. 17. *Prosthiostomum bellum;* arrangement of eyes. ×22.

scattered numerous brown spots. The cerebral group of eyes consists of about 40 ocelli, which are separated into two clusters by the median line. There are two pairs of ventral eyes. The marginal eyes are rather densely distributed along the frontal margin, except in the small area near the median depression. The mouth lies just behind the brain, and leads into a long cylindrical pharynx, which is much folded in the contracted state (Pl. IV, Fig. 2). The anterior median branch of the intestine is very rudimentary. The sucker is situated in the middle of the body.
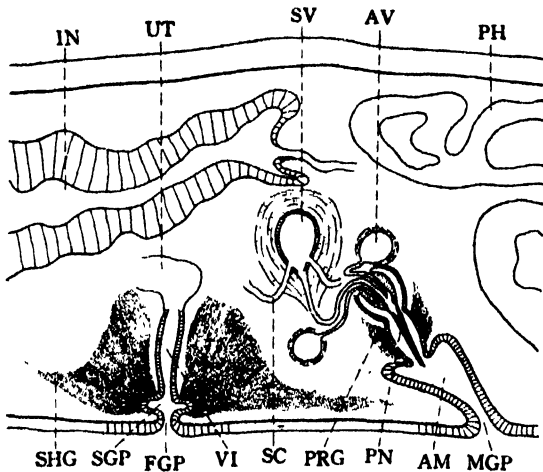
Fig. 18. *Prosthiostomum bellum;* sagittal section through genital organs. ×70.

The arrangement of the genital organs is closely similar to that found in other species of this genus as shown in figure 18. The seminal vesicle is large, and receives a pair of seminal canals near the exit of its efferent duct. The paired accessory vesicles open by each narrow canal into the ejaculatory duct at the base of the penis.

This species is characterized by the arrangement of the eyes.

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EXPLANATION OF PLATES

ABBREVIATIONS

AM antrum masculinum; AV accessory vesicle; BR brain; CG cyanophilous gland; CUD common uterine duct; ED ejaculatory duct; EG egg; FGP female genital pore; FSV false seminal vesicle; IN intestine; LGV Lang's glandular vesicle; MGP male genital pore; MO mouth; MW muscular wall; PH pharynx; PN penis; PNS penis sheath; PRG prostate gland; PRV prostate vesicle; SC seminal canal; SGD shell gland duct; SHG shell gland; SP sperm; SV seminal vesicle; UT uterus; VB vagina bulbosa; VE vagina externa; VI vagina interna; ♂ male genital pore; ♀ female genital pore.

PLATE III

1. *Plehnia pacifica*, sp. nov., anterior half of body. ×7
2. Ditto, sagittal section through genital organs. ×25
3, 4. Ditto, sagittal section through genital organs. ×40
5. *Notoplana sophia*, sp. nov., eye-spots. ×26
6. *Pseudostylochus takeshitai* YERI et KABURAKI, sagittal section through genital organs. ×25

PLATE IV

1. *Prosthiostomum bellum*, sp. nov., anterior end of body. ×15
2. Ditto, sagittal section through genital organs. ×40
3. *Notoplana libera*, sp. nov., sagittal section through genital organs. ×40
4. Ditto, eye-spots. ×25
5. *Notoplana sophia*, sp. nov., sagittal section through genital organs. ×40
6. *Pseudostylochus nationalis*, sp. nov., sagittal section through genital organs. ×25

K. KATO: Polyclads in Onagawa and Vicinity.
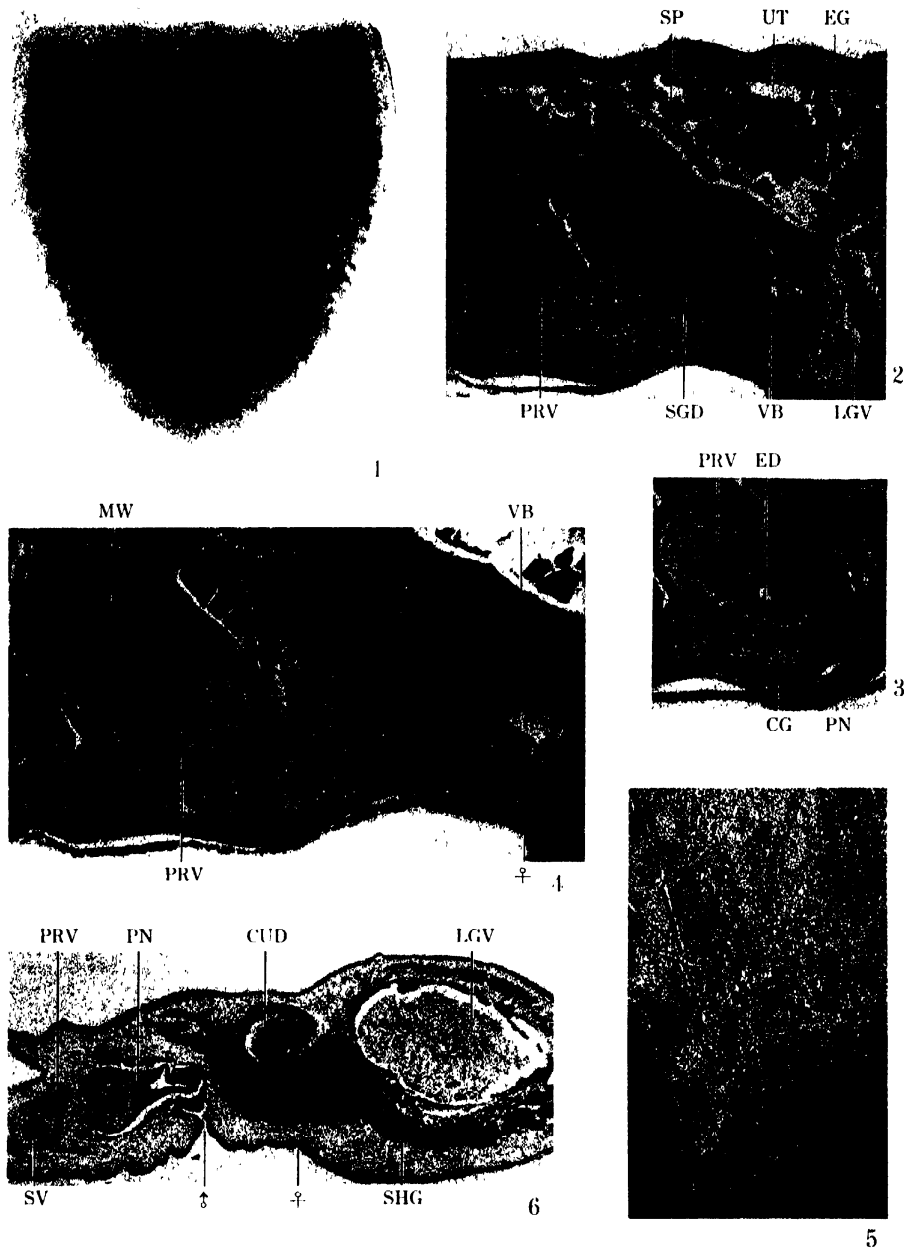
K. Kato : Polyclads in Onagawa and Vicinity.
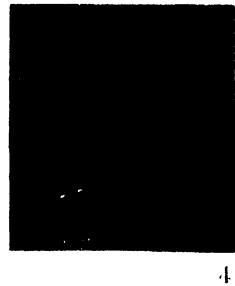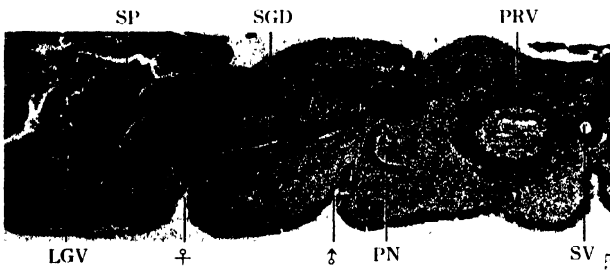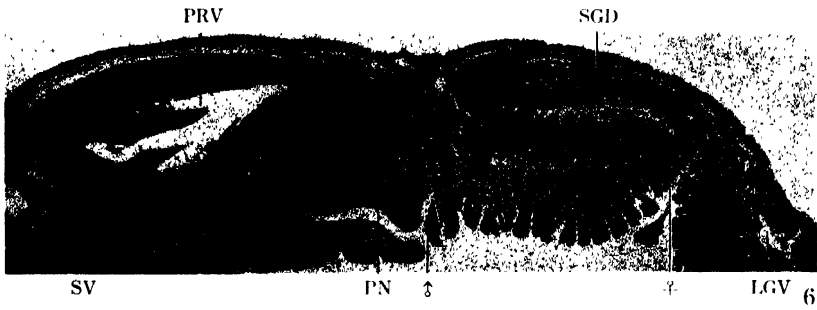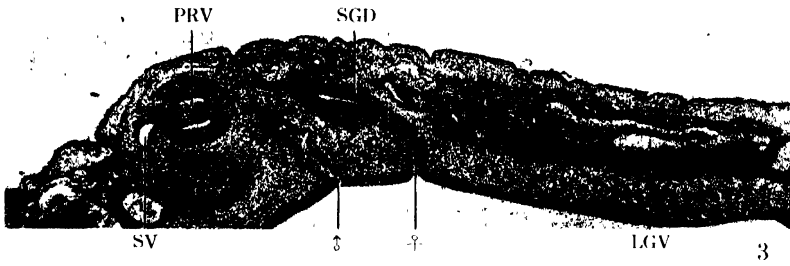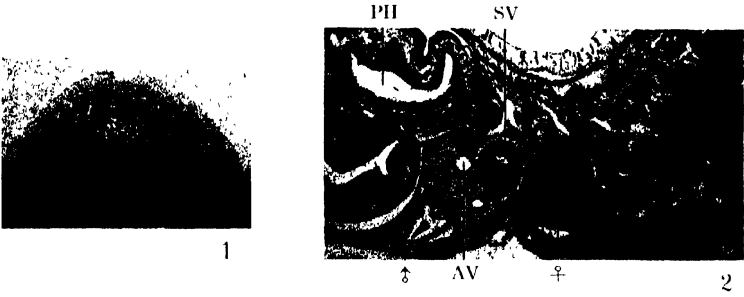
FURTHER STUDIES OF THE VARIABILITY IN THE POSITION AND NUMBER OF MALE AND SPERMATHECAL PORES IN THE CASE OF *PHERETIMA IRREGULARIS* BASED UPON LOCAL ANALYSES

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(With 5 text-figures)

(Received March 18, 1939)

Pheretima irregularis (GOTÔ and HATAI) am. OHFUCHI, which occurs abundantly in the Ôu Region, or the north-eastern part of Honshû, Japan, is characterised by the position, by the number, and by the presence or absence of the spermathecal and male pores as noted in my preceding paper (1938). At first, the distinction between *Pheretima irregularis* (GOTÔ and HATAI) and *Pheretima levis* (GOTÔ and HATAI) was made by the nomenclators according to the absence, or to the presence of two pairs, of spermathecae, respectively. In examining a large number of both species, however, there were found many specimens having intermediate characteristics, and finally they have been united into one species, *Pheretima irregularis* (GOTÔ and HATAI) am. OHFUCHI, which shows variations regarding the position and number of the genital pores. Soon after the publication of my paper, the validity of the identification of these species was recognized also by KOBAYASHI (1938).

Hitherto, no reports have appeared which have bearing on the local variation in the presence or absence of the spermathecal pores in the genus *Pheretima*. BEDDARD (1886) described a remarkable series of variations, which he observed on the external genital marks, i. e. the male, the female and the spermathecal pores, and the clitellum of *Perionyx excavatus* PERRIER, and noticed also the translation of the internal genital organs as well as the shifting of the external genital markings. MORGAN (1895) studied variations in the location of the male pores in some Lumbricids. HORST (1899) gave examples of variation in the number of genital papillae principally in *Pheretima biserialis* (PERRIER) = *elongata* (PERRIER) and *Pheretima Stelleri* (MICHAELSEN), and found that, in the former species, the spermathecae, normally in two pairs in the segments VI and VII, may

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be absent altogether, while there are often more than a pair per segment, e. g. three or four on the right side only of the two segments; and that, in the latter species, the majority posess more than one pair of spermathecae on each side of the two segments: the actual number is very variable, the largest number in one segment being 29, 12 on the left and 17 on the right side. BEDDARD and FEDARB (1899) confirmed the variability in the spermathecae of *Pheretima elongata* (PERRIER). SMITH (1922) reports variations in the position of genital pores, and PICKFORD (1926) reports variations in the position of genital papillae in the cases of some Lumbricid species. GATES (1926) describes the variability in the number and situation of the spermathecal pores of *Pheretima elongata.*

It is clear that such variations in body structure are due, or at least related, to the climatic or environmental factors in the natural habitat. Consequently, it is reasonable to believe that these variations have close relation to the influence of environment. In fact, in the case of Oligo-chaeta, it appears that the reproductive system is markedly sensitive to the effect of environmental factors, and that the variations are related in some degree to the habitat. An investigation into *Pheretima irregularis* therefore was undertaken from this standpoint — that the position and number of the genital pores in this species are affected by climatic and local conditions. ·

This investigation, based upon 3,220 specimens collected in the Ôu Region, proved that there is a comparatively regular range of variation from the northern to the southern part of that region. In the present paper, therefore, I wish to deal with the origin, if possible, of the various types of the variation in order to find why these types occur according to localities, and also in order to determine what correlation can be found between variations and environment.

Before proceeding further, I wish to express my hearty thanks to Dr. S. HATAI for his valuable suggestions, to Mr. K. OKADA for his unstinted encouragement, and to Miss FUMI GOTÔ for her faithful assistance, given me during the course of this study. I have also to offer my warmest thanks to Prof. Dr. E. NOMURA for his helpful advice while I was pre-paring for the publication of the present paper.

MATERIALS AND LOCALITIES

The materials used in this investigation were mostly those which were collected from July to October, 1934–1937, and used in my study of 1938. Additional materials were added in the summer of 1938.

This worm begins to appear from April to May in its natural habitat and attains sexual maturity in July. It disappears generally in the regions of North Japan in the autumn probably owing to death. My specimens
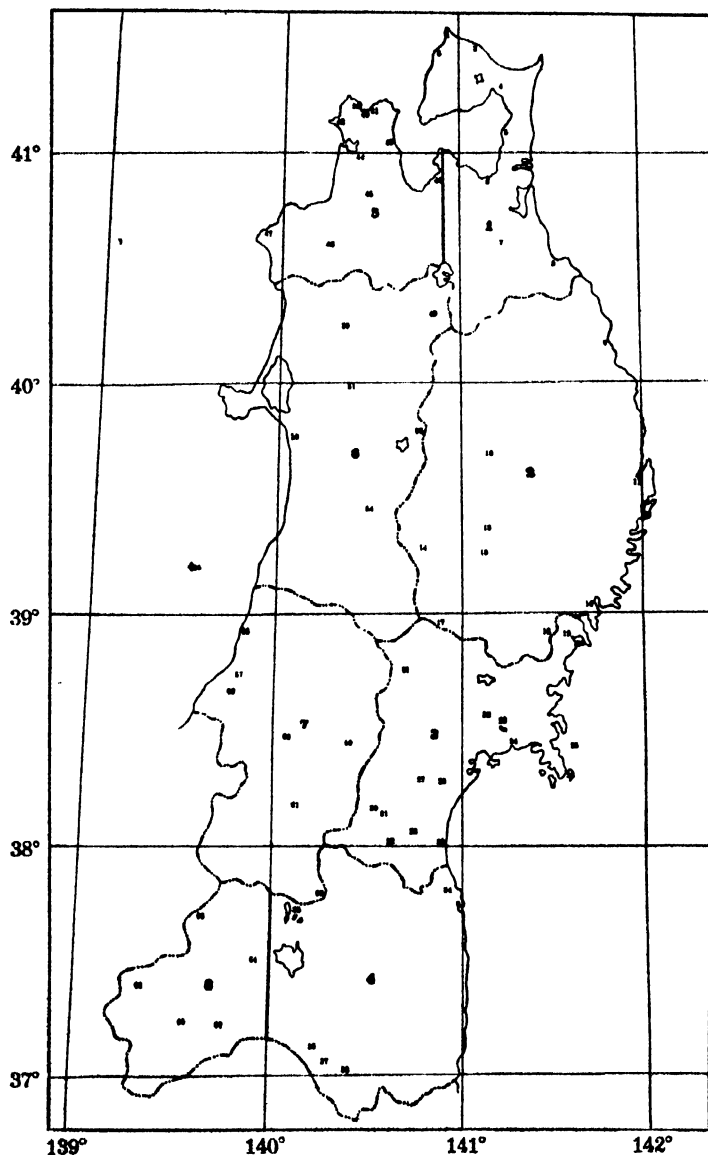
Fig. 1. A map of the Ôu Region, showing the localities of actual collection in the eight subdivisions. Each locality is denoted by a numerical mark, the key of which is given in Table 1.

therefore had without exception been hatched in the spring of the year
in which they were collected.

For the convenience of local analyses, the Ôu Region is divided into
two well-marked districts, viz. the Pacific Division and the Japan Sea
Division which lie respectively east and west of the Ôu mountain range,
which runs nearly longitudinally down the centre, and which forms the
main watershed, of the Ôu Region. These two divisions are distinctly
recognizable from each other according to a remarkable difference of
rainfall in summer and winter. Each division is then subdivided into
four subdivisions, mainly, according to the administrative sections. The
subdivisions in the Aomori Prefecture are made by the longitude passing
through the northernmost end of Natsudomari Peninsula, and those in the
Fukushima Prefecture by the longitude 140° E. (Fig. 1). The local names
and the numbers of worms examined in the different localities are tabulated
in Table 1.

TABLE 1

Sub-division	Prefecture	Mark of locality in Fig. 1	Locality	Number of worms examined
1	Aomori	1	Ôma, Shimokita District	31
		2	Shimofuro, ditto.	42
		3	Sai, ditto.	24
		4	Tanabu, ditto.	12
		5	Yokohama, Kamikita District	41
		6	Noheji, ditto.	43
		7	Sambongi, ditto.	41
		8	Hachinohe, Sannohe District	61
	Total number of worms examined in Subdivision 1			295
2	Iwate	9	Kuji, Kunohe District	57
		10	Morioka, Iwate District	27
		11	Miyako, Shimohei District	112
		12	Funakoshi, ditto.	51
		13	Hanamaki, Hienuki District	46
		14	Kawajiri, Waga District	100
		15	Kurosawajiri, ditto.	7
		16	Ôfunato, Kesen District	9
		17	Zuizan, Nishi-iwai District	18
		18	Orikabe, Higashi-iwai District	95
	Total number of worms examined in Subdivision 2			522

Sub-division	Prefecture	Mark of locality in Fig. 1	Locality	Number of worms examined
3	Miyagi	19	Kesennuma, Motoyoshi District	95
		20	Ôshima, ditto.	7
		21	Nakayama-daira, Tamatsukuri District	83
		22	Wakuya, Tôda District	83
		23	Maeyachi, Monô District	46
		24	Ishinomaki, Ojika District	19
		25	Enoshima, ditto.	2
		26	Kinka-zan, ditto.	6
		27	Ayashi, Miyagi District	27
		28	Sendai, ditto.	39
		29	Ôkawara, Shibata District	31
		30	Aone, ditto.	22
		31	Tôgatta, Katta District	25
		32	Shiroishi, ditto.	57
		33	Hamayoshida, ditto.	71
Total number of worms examined in Subdivision 3				613
4	Fukushima	34	Nakamura, Sôma District	131
		35	Foot of Mt. Azuma, Yama District	25
		36	Shirakawa, Nishi-shirakawa District	32
		37	Kanayama, ditto.	146
		38	Tanakura, Higashi-shirakawa District	22
Total number of worms examined in Subdivision 4				356
5	Aomori	39	Mimmaya, Higashi-tsugaru District	41
		40	Imabetsu, ditto.	50
		41	Hamana, ditto.	36
		42	Kodomari, Kita-tsugaru District	35
		43	Kanita, Higashi-tsugaru District	37
		44	Nakazato, Kita-tsugaru District	4
		45	Goshogawara, ditto.	37
		46	Asamushi, Higashi-tsugaru District	28
		47	Fukaura, Nishi-tsugaru District	4
		48	Nishimeya, Naka-tsugaru District	7
Total number of worms examined in Subdivision 5				279
6	Akita	49	Ôyu, Kazuno District	73
		50	Takanosu, Kita-akita District	35
		51	Arase, ditto.	74
		52	Tsuchizaki, Minami-akita District	32
		53	Foot of Mt. Komagadake, Sempoku District	57
		54	Ômagari, ditto.	19
Total number of worms examined in Subdivision 6				290

Sub-division	Prefecture	Mark of locality in Fig. 1	Locality	Number of worms examined
7	Yamagata	55	Tobi-shima, Akumi District	27
		56	Sakata, ditto.	64
		57	Tsuruoka, Higashi-tagawa District	108
		58	Kogane, ditto.	29
		59	Higashine, Kita-murayama District	33
		60	Hondôji, Nishi-okitama District	37
		61	Arato, ditto.	79
		62	Goshiki, Minami-okitama District	53
Total number of worms examined in Subdivision 7				430
8	Fukushima	63	Tokuzawa, Kanuma District	105
		64	Wakamatsu, Kita-aizu District	32
		65	Yamaguchi, Minami-aizu District	34
		66	Tadami, ditto.	176
		67	Tajima, ditto.	88
Total number of worms examined in Subdivision 8				435
Total number of worms examined in the whole region of Ôu				3220

VARIATIONS IN THE NUMBER AND POSITION OF THE SPERMATHECAL AND MALE PORES

In the case of *Pheretima irregularis*, the spermathecal pores are often entirely absent. When present, however, they are found limited to the intersegmental furrows VI/VII and VII/VIII, one or two on one side, or one or two pairs on both sides, of the body. Therefore, the cases of the presence or absence of the spermathecal pores can be grouped into three, viz. the case of entire absence (I, Fig. 2), the case of presence on both sides (II, Fig. 3), and the case of presence on left or right side only (III, Fig. 4). Since the number and position of the spermathecal pores had up to this time been considered taxonomically to be an invariable and important characteristic of *Pheretima irregularis*, I was intensely interested in studying the pores of this species in this new light.

The types shown in Figs. 3 and 4 are grouped tentatively according to the presence of the spermathecal pore or pores on VI/VII or VII/VIII respectively, in order to determine which furrow was the dominant position in the occupation of the spermathecal pores.

The male pores of the present species are also often absent. When present, they are confined invariably to the segment XVIII, one on one

side, or one pair on both sides, of the body. Therefore, the cases of the presence or absence of male pores may be grouped into three, as in the
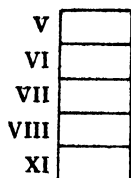
Fig. 2. Diagrammatic representation of specimens
without any spermathecal pores.
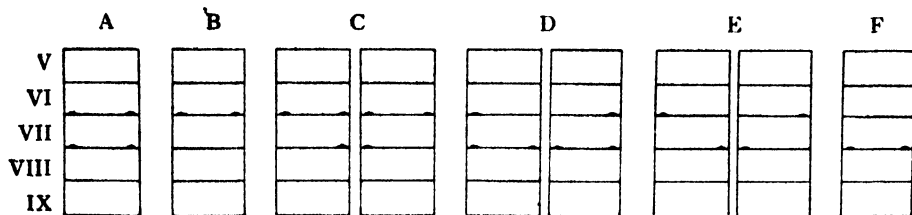
Fig. 3. Diagrammatic representations of specimens with spermathecal pores on both sides of the body, showing the six types of variation.
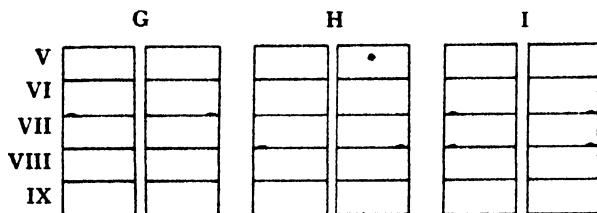
Fig. 4. Diagrammatic representations of specimens with spermathecal pores on one side of the body, showing the three types of variation.

cases of the spermathecal pores, viz. the case of entire absence (a), the case of presence on both sides (b), and the case of presence on one side (c).

It is noticeable here that, when the male or spermathecal pore was present, there was also present, without exception, the corresponding internal organ, viz. the prostate gland or the spermatheca respectively, but when these pores were absent these organs were also absent. This was ascertained by internal dissection of every specimen.

Besides *Pheretima irregularis*, such species, viz. *Pheretima agrestis* (GOTÔ and HATAI), *Pheretima vittata* (GOTÔ and HATAI), *Pheretima yunoshimensis* HATAI, *Pheretima divergens* (MICHAELSEN), and *Pheretima hilgendorfi* (MICHAELSEN) are known to have cases of the entire absence of male pore or of the presence of them on one side of the body.

The variability of the spermathecal pores in combination with that of the male pores in every subdivision is shown in the respective table from 2 to 9.

TABLE   2

Subdivision 1

Presence or absence of spermathecal pores		Number of specimens	Percentage per 295 specimens	Presence or absence of male pores		Number of specimens	Percentage per 295 specimens
I Entire absence		178	60.3	Entire absence	a	158	53.6
				Presence on both sides	b	6	2.0
				Presence on one side	c	14	4.7
II Presence on both sides	A	34	11.5	Entire absence	a	19	6.4
				Presence on both sides	b	6	2.0
				Presence on one side	c	9	3.1
	B	14	4.7	Entire absence	a	10	3.4
				Presence on both sides	b	2	0.7
				Presence on one side	c	2	0.7
	C	13	4.4	Entire absence	a	8	2.7
				Presence on both sides	b	2	0.7
				Presence on one side	c	3	1.0
	D	8	2.7	Entire absence	a	5	1.7
				Presence on both sides	b	2	0.7
				Presence on one side	c	1	0.3
	E	4	1.4	Entire absence	a	2	0.7
				Presence on both sides	b	1	0.3
				Presence on one side	c	1	0.3
	F	2	0.7	Entire absence	a	1	0.3
				Presence on both sides	b	0	0.0
				Presence on one side	c	1	0.3
III Presence on one side	G	21	7.1	Entire absence	a	12	4.1
				Presence on both sides	b	4	1.4
				Presence on one side	c	5	1.7
	H	13	4.4	Entire absence	a	9	3.1
				Presence on both sides	b	2	0.7
				Presence on one side	c	2	0.7
	I	8	2.7	Entire absence	a	5	1.7
				Presence on both sides	b	2	0.7
				Presence on one side	c	1	0.3

TABLE 3

Subdivision 2

Presence or absence of spermathecal pores		Number of specimens	Percentage per 522 specimens	Presence or absence of male pores		Number of specimens	Percentage per 522 specimens
I Entire absence		313	60.0	Entire absence	a	236	45.1
				Presence on both sides	b	26	5.0
				Presence on one side	c	51	9.8
II Presence on both sides	A	35	6.7	Entire absence	a	23	4.4
				Presence on both sides	b	5	1.0
				Presence on one side	c	7	1.3
	B	32	6.1	Entire absence	a	14	2.7
				Presence on both sides	b	8	1.5
				Presence on one side	c	10	1.9
	C	33	6.3	Entire absence	a	15	2.9
				Presence on both sides	b	10	1.9
				Presence on one side	c	8	1.5
	D	14	2.7	Entire absence	a	8	1.5
				Presence on both sides	b	3	0.6
				Presence on one side	c	3	0.6
	E	13	2.5	Entire absence	a	8	1.5
				Presence on both sides	b	3	0.6
				Presence on one side	c	2	0.4
	F	3	0.6	Entire absence	a	1	0.2
				Presence on both sides	b	1	0.2
				Presence on one side	c	1	0.2
III Presence on one side	G	43	8.2	Entire absence	a	23	4.4
				Presence on both sides	b	10	1.9
				Presence on one side	c	10	1.9
	H	23	4.4	Entire absence	a	10	1.9
				Presence on both sides	b	4	0.8
				Presence on one side	c	9	1.7
	I	13	2.5	Entire absence	a	6	1.1
				Presence on both sides	b	3	0.6
				Presence on one side	c	4	0.8

TABLE   4

Presence or absence of spermathecal pores		Number of specimens	Percentage per 613 specimens	Presence or absence of male pores		Number of specimens	Percentage per 613 specimens
I Entire absence		339	55.3	Entire absence	a	217	35.4
				Presence on both sides	b	47	7.7
				Presence on one side	c	75	12.2
II Presence on both sides	A	60	9.8	Entire absence	a	43	7.0
				Presence on both sides	b	9	1.4
				Presence on one side	c	8	1.3
	B	40	6.5	Entire absence	a	21	3.4
				Presence on both sides	b	8	1.3
				Presence on one side	c	11	1.8
	C	47	7.7	Entire absence	a	30	4.9
				Presence on both sides	b	7	1.1
				Presence on one side	c	10	1.6
	D	15	2.4	Entire absence	a	11	1.8
				Presence on both sides	b	3	0.5
				Presence on one side	c	1	0.2
	E	9	1.4	Entire absence	a	2	0.3
				Presence on both sides	b	2	0.3
				Presence on one side	c	5	0.8
	F	3	0.5	Entire absence	a	3	0.5
				Presence on both sides	b	0	0.0
				Presence on one side	c	0	0.0
III Presence on one side	G	51	8.3	Entire absence	a	35	5.7
				Presence on both sides	b	9	1.4
				Presence on one side	c	7	1.1
	H	29	4.7	Entire absence	a	19	3.1
				Presence on both sides	b	6	1.0
				Presence on one side	c	4	0.7
	I	20	3.3	Entire absence	a	13	2.1
				Presence on both sides	b	3	0.5
				Presence on one side	c	4	0.7

TABLE 5

Subdivision 4

Presence or absence of spermathecal pores		Number of specimens	Percentage per 356 specimens	Presence or absence of male pores		Number of specimens	Percentage per 356 specimens
I Entire absence		192	53.9	Entire absence	a	142	39.8
				Presence on both sides	b	18	5.3
				Presence on one side	c	32	9.0
II Presence on both sides	A	33	9.2	Entire absence	a	26	7.3
				Presence on both sides	b	3	0.8
				Presence on one side	c	4	1.1
	B	27	7.6	Entire absence	a	24	6.7
				Presence on both sides	b	2	0.6
				Presence on one side	c	1	0.3
	C	32	9.0	Entire absence	a	21	5.9
				Presence on both sides	b	5	1.4
				Presence on one side	c	6	1.7
	D	4	1.1	Entire absence	a	3	0.8
				Presence on both sides	b	1	0.3
				Presence on one side	c	0	0.0
	E	6	1.7	Entire absence	a	5	1.4
				Presence on both sides	b	1	0.3
				Presence on one side	c	0	0.0
	F	2	0.6	Entire absence	a	1	0.3
				Presence on both sides	b	1	0.3
				Presence on one side	c	0	0.0
III Presence on one side	G	33	9.2	Entire absence	a	30	8.4
				Presence on both sides	b	1	0.3
				Presence on one side	c	2	0.6
	H	17	4.8	Entire absence	a	12	3.4
				Presence on both sides	b	3	0.8
				Presence on one side	c	2	0.6
	I	10	2.8	Entire absence	a	7	1.9
				Presence on both sides	b	2	0.6
				Presence on one side	c	1	0.3

TABLE　6

Subdivision 5

Presence or absence of spermathecal pores		Number of specimens	Percentage per 279 specimens	Presence or absence of male pores		Number of specimens	Percentage per 279 specimens
I Entire absence		215	77.1	Entire absence	a	159	57.0
				Presence on both sides	b	10	3.6
				Presence on one side	c	46	16.5
II Presence on both sides	A	11	3.9	Entire absence	a	5	1.8
				Presence on both sides	b	3	1.1
				Presence on one side	c	3	1.1
	B	8	2.9	Entire absence	a	5	1.8
				Presence on both sides	b	1	0.4
				Presence on one side	c	2	0.7
	C	4	1.4	Entire absence	a	3	1.1
				Presence on both sides	b	1	0.4
				Presence on one side	c	0	0.0
	D	3	1.1	Entire absence	a	2	0.7
				Presence on both sides	b	0	0.0
				Presence on one side	c	1	0.4
	E	3	1.1	Entire absence	a	2	0.7
				Presence on both sides	b	0	0.0
				Presence on one side	c	1	0.4
	F	2	0.7	Entire absence	a	1	0.4
				Presence on both sides	b	1	0.4
				Presence on one side	c	0	0.0
III Presence on one side	G	18	6.5	Entire absence	a	11	3.9
				Presence on both sides	b	3	1.1
				Presence on one side	c	4	1.4
	H	11	3.9	Entire absence	a	7	2.5
				Presence on both sides	b	1	0.4
				Presence on one side	c	3	1.1
	I	4	1.4	Entire absence	a	2	0.7
				Presence on both sides	b	1	0.4
				Presence on one side	c	1	0.4

TABLE 7

Subdivision 6

Presence or absence of spermathecal pores		Number of specimens	Percentage per 290 specimens	Presence or absence of male pores		Number of specimens	Percentage per 290 specimens
I Entire absence		211	72.8	Entire absence	a	144	49.7
				Presence on both sides	b	18	6.3
				Presence on one side	c	49	16.9
II Presence on both sides	A	10	3.4	Entire absence	a	6	2.1
				Presence on both sides	b	2	0.7
				Presence on one side	c	2	0.7
	B	6	2.1	Entire absence	a	3	1.0
				Presence on both sides	b	2	0.7
				Presence on one side	c	1	0.3
	C	8	2.8	Entire absence	a	5	1.7
				Presence on both sides	b	1	0.3
				Presence on one side	c	2	0.7
	D	3	1.0	Entire absence	a	2	0.7
				Presence on both sides	b	1	0.3
				Presence on one side	c	0	0.0
	E	3	1.0	Entire absence	a	2	0.7
				Presence on both sides	b	0	0.0
				Presence on one side	c	1	0.3
	F	2	0.7	Entire absence	a	1	0.3
				Presence on both sides	b	1	0.3
				Presence on one side	c	0	0.0
III Presence on one side	G	24	8.3	Entire absence	a	15	5.2
				Presence on both sides	b	5	1.7
				Presence on one side	c	4	1.4
	H	15	5.2	Entire absence	a	9	3.1
				Presence on both sides	b	2	0.7
				Presence on one side	c	4	1.4
	I	8	2.8	Entire absence	a	5	1.7
				Presence on both sides	b	2	0.7
				Presence on one side	c	1	0.3

TABLE   8

Subdivision 7

Presence or absence of spermathecal pores		Number of specimens	Percentage per 430 specimens	Presence or absence of male pores		Number of specimens	Percentage per 430 specimens
I Entire absence		288	67.0	Entire absence	a	171	39.6
				Presence on both sides	b	32	7.4
				Presence on one side	c	85	19.8
II Presence on both sides	A	18	4.0	Entire absence	a	12	2.8
				Presence on both sides	b	3	0.7
				Presence on one side	c	3	0.7
	B	11	2.6	Entire absence	a	5	1.2
				Presence on both sides	b	3	0.7
				Presence on one side	c	3	0.7
	C	17	4.0	Entire absence	a	10	2.3
				Presence on both sides	b	4	0.9
				Presence on one side	c	3	0.7
	D	12	2.9	Entire absence	a	7	1.6
				Presence on both sides	b	3	0.7
				Presence on one side	c	2	0.5
	E	9	2.1	Entire absence	a	4	0.9
				Presence on both sides	b	2	0.5
				Presence on one side	c	3	0.7
	F	3	0.7	Entire absence	a	1	0.2
				Presence on both sides	b	1	0.2
				Presence on one side	c	1	0.2
III Presence on one side	G	41	9.5	Entire absence	a	32	7.4
				Presence on both sides	b	4	0.9
				Presence on one side	c	5	1.2
	H	11	2.6	Entire absence	a	7	1.6
				Presence on both sides	b	2	0.5
				Presence on one side	c	2	0.5
	I	20	4.7	Entire absence	a	12	2.9
				Presence on both sides	b	5	1.2
				Presence on one side	c	3	0.7

TABLE 9

Subdivision 8

Presence or absence of spermathecal pores		Number of specimens	Percentage per 435 specimens	Presence or absence of male pores		Number of specimens	Percentage per 435 specimens
I Entire absence		288	66.2	Entire absence	a	187	43.0
				Presence on both sides	b	18	4.1
				Presence on one side	c	83	19.1
II Presence on both sides	A	26	6.0	Entire absence	a	20	4.6
				Presence on both sides	b	2	0.5
				Presence on one side	c	4	0.9
	B	22	5.1	Entire absence	a	13	3.0
				Presence on both sides	b	4	0.9
				Presence on one side	c	5	1.1
	C	22	5.1	Entire absence	a	15	3.4
				Presence on both sides	b	4	0.9
				Presence on one side	c	3	0.7
	D	7	1.6	Entire absence	a	6	1.4
				Presence on both sides	b	1	0.2
				Presence on one side	c	0	0.0
	E	2	0.5	Entire absence	a	2	0.5
				Presence on both sides	b	0	0.0
				Presence on one side	c	0	0.0
	F	2	0.5	Entire absence	a	1	0.2
				Presence on both sides	b	0	0.0
				Presence on one side	c	1	0.2
III Presence on one side	G	28	6.4	Entire absence	a	20	4.6
				Presence on both sides	b	4	0.9
				Presence on one side	c	4	0.9
	H	22	5.1	Entire absence	a	12	2.8
				Presence on both sides	b	4	0.9
				Presence on one side	c	6	1.4
	I	16	3.7	Entire absence	a	10	2.3
				Presence on both sides	b	3	0.7
				Presence on one side	c	3	0.7

In Tables 2–9, it is evident that the specimens, in which the male and the spermathecal pores were entirely absent, were dominant in number invariably in each subdivision. Moreover, among the specimens having the spermathecal pores on both sides, those having two pairs on the intersegmental furrows VI/VII and VII/VIII (A), those having one pair on VI/VII (B), and those having one pair on VI/VII and one on one side of VII/VIII (C) showed a large number invariably in each subdivision in comparison with the other types. Again, among the specimens having the spermathecal pores on one side only, those having one on one side of VI/VII (G) showed large numbers in comparison with the others.

CHANGE OF THE VARIABILITY IN THE PACIFIC DIVISION

In Table 10, the percentage number of specimens in every variation of the spermathecal pores, which occurred in each subdivision of the Pacific Division, is shown, the data being recapitulated from the respective table from 2 to 5. In this table, the percentage number showed a decrease from the northern to the southern subdivision in I and IID, and perhaps in IIA. On the contrary, the percentage number showed an increase from the northern to the southern subdivision in IIB, IIC, IIIG and IIIH. In the others, the tendency of either decrease or increase is indeterminable.

TABLE 10

Percentage numbers of the specimens in the three cases of the spermathecal pores in every subdivision of the Pacific Division

Presence or absence of spermathecal pores		Subdivision 1	Subdivision 2	Subdivision 3	Subdivision 4
I. Entire absence		60.3	60.0	55.3	53.9
II. Presence on both sides	A	11.5	6.7	9.8	9.2
	B	4.7	6.1	6.5	7.6
	C	4.4	6.3	7.7	9.0
	D	2.7	2.7	2.4	1.1
	E	1.4	2.5	1.4	1.7
	F	0.7	0.6	0.5	0.6
III. Presence on one side	G	7.1	8.2	8.3	9.2
	H	4.4	4.4	4.7	4.8
	I	2.7	2.5	3.3	2.8

In Table 11, the percentage number of specimens in every variation of the male pores in combination with the three cases of the spermathecal pores, which occurred in each subdivison of the Pacific Division, is shown, the data being recapitulated also from the respective table from 2 to 5. In this table, the percentage number showed a decrease from the northern

TABLE 11

Percentage numbers of the specimens in the three cases of the male pores in combination with the three cases of the spermathecal pores in each subdivision of the Pacific Division

Presence or absence of spermathecal pores		Presence or absence of male pores	Subdivision 1	Subdivision 2	Subdivision 3	Subdivision 4
I. Entire absence		a	53.6	45.1	35.4	39.8
		b	2.0	5.0	7.7	5.3
		c	4.7	9.8	12.2	9.0
II. Presence on both sides	A	a	6.4	4.4	7.0	7.3
		b	2.0	1.0	1.4	0.8
		c	3.1	1.3	1.3	1.1
	B	a	3.4	2.7	3.4	6.7
		b	0.7	1.5	1.3	0.6
		c	0.7	1.9	1.8	0.3
	C	a	2.7	2.9	4.9	5.9
		b	0.7	1.9	1.1	1.4
		c	1.0	1.5	1.6	1.7
	D	a	1.7	1.5	1.8	0.8
		b	0.7	0.6	0.5	0.3
		c	0.3	0.6	0.2	0.0
	E	a	0.7	1.5	0.3	1.4
		b	0.3	0.6	0.3	0.3
		c	0.3	0.4	0.8	0.0
	F	a	0.3	0.2	0.5	0.3
		b	0.0	0.2	0.0	0.3
		c	0.3	0.2	0.0	0.0
III. Presence on one side	G	a	4.1	4.4	5.7	8.4
		b	1.4	1.9	1.4	0.3
		c	1.7	1.9	1.1	0.6
	H	a	3.1	1.9	3.1	3.4
		b	0.7	0.8	1.0	0.8
		c	0.7	1.7	0.7	0.6
	I	a	1.7	1.1	2.1	1.9
		b	0.7	0.6	0.5	0.6
		c	0.3	0.8	0.7	0.3

to the southern subdivision in IIAc, IIDb and IIFc, and perhaps in Ia.
On the contrary, the percentage number showed an increase in IICa,
IICc and IIIGa, and perhaps in IIAa and IIBa.   In the others, the
tendency is indeterminable, even through the percentage number may
show a decrease or an increase from Subdivision 1 to Subdivison 2 or 3
and then an increase or a decrease to Subdivision 4 respectively.

As the tendencies are shown to be too widely different in the types of
II and of III, Table 12 has been made in order to see what change of
the spermathecal pores would show, as a whole, in II and III, and, within
the respective limit, to know to what extent the male pores would change
in variability according to each subdivision of the Pacific Division.   The
data given in this table are the percentage numbers of the specimens
summed up in the corresponding places of the respective table from 2
to 5.

TABLE   12

*Percentage numbers of the specimens summed up in whole case
of II and of III and in the respective cases of a, b, c
in each subdivision of the Pacific Division*

Presence or absence of male pores		Subdivision 1	Subdivision 2	Subdivision 3	Subdivision 4
II		25.4	24.9	28.4	29.2
Entire absence	a	15.3	13.2	17.9	22.5
Presence on both sides	b	4.4	5.7	4.7	3.7
Presence on one side	c	5.8	5.9	5.7	3.1
III		14.2	15.1	16.3	16.9
Entire absence	a	8.8	7.5	11.0	13.8
Presence on both sides	b	2.7	3.3	2.9	1.7
Presence on one side	c	2.7	4.4	2.4	1.4

In the case of II, Table 12 reveals that the percentage number of
the specimens, possessing the spermathecal pores on both sides of the
body, tended to increase from the northern to the southern subdivision,
and that, within this same limit, the specimens without male pores tended
to increase (a), those having them on both sides tended to decrease (b),
and those having a pore on one side tended also to decrease (c), from
the northern to the southern subdivision.

In the case of III, Table 12 reveals that the percentage number of

the specimens, having the spermathecal pore or pores on one side of the body, tended to increase southwards, and that, within this limit, the specimens without male pores showed a decrease from Subdivision 1 to Subdivision 2 and then an increase to Subdivision 4 (a), while those having them on both sides (b) and those having a pore on one side (c) showed an increase from Subdivision 1 to Subdivision 2 and then a decrease to Subdivision 4.

TABLE 13

Percentage numbers of the specimens, having spermathecal pores
· on VI/VII (BC), and having those on VII/VIII (DF),
in each subdivision of the Pacific Division

	Subdivision 1	Subdivision 2	Subdivision 3	Subdivision 4
BC	9.2	12.5	14.1	16.6
DF	3.4	3.3	2.3	1.7

Table 13 has been made in order to show the relation between the numbers of the specimens having a pair of spermathecal pores on VI/VII (BC) and having a pair on VII/VIII (DF). The data given in this table are the percentage numbers of the specimens summed up in the corresponding places of the respective table from 2 to 5. This table shows that BC was always greater than DF, and that BC increased while DF decreased from the northern to the southern subdivision.

TABLE 14

Percentage numbers of the specimens, in which the male pores are
entirely absent (a), present on both sides (b) and present on
one side of the body (c), being examined in each
subdivision of the Pacific Division

Presence or absence of male pores		Subdivision 1	Subdivision 2	Subdivision 3	Subdivision 4
Entire absence	a	77.6	65.9	64.3	76.1
Presence on both sides	b	9.2	14.0	15.3	13.5
Presence on one side	c	13.2	20.1	20.4	10.4

Table 14 has been made in order to show the change of variability in the male pores. The data are the percentage numbers of the specimens summed up, all a, all b and all c, respectively, in each subdivision of the Pacific Division given in the respective table from 2 to 5.

CHANGE OF THE VARIABILITY IN THE JAPAN SEA DIVISION

In Table 15, the percentage number of specimens in every variation of the spermathecal pores, which occurred in each subdivision of the Japan Sea Division, is shown, the data being recapitulated from the respective table from 6 to 9. In this table, the percentage number showed a decrease from the northern to the southern subdivision in I and IIF. On the contrary, the percentage number showed an increase from the northern to the southern subdivision in IIC, and perhaps in IIA and IIB. In the others, the tendency of change is indeterminable, even though the percentage number may show either a decrease or an increase from Subdivision 5 to Subdivision 6 or 7 and then an increase or a decrease to Subdivision 8 respectively.

TABLE   15

Percentage numbers of the specimens in the three cases of the spermathecal pores in every subdivision of the Japan Sea Division

Presence or absence of spermathecal pores		Subdivision 5	Subdivision 6	Subdivision 7	Subdivision 8
I. Entire absence		77.1	72.8	67.0	66.2
II. Presence on both sides	A	3.9	3.4	4.0	6.0
	B	2.9	2.1	2.6	5.1
	C	1.4	2.8	4.0	5.1
	D	1.1	1.0	2.9	1.6
	E	1.1	1.0	2.1	0.5
	F	0.7	0.7	0.7	0.5
III. Presence on one side	G	6.5	8.3	9.5	6.4
	H	3.9	5.2	2.6	5.1
	I	1.4	2.8	4.7	3.7

In Table 16, the percentage number of specimens in every variation of the male pores in combination with the three cases of the spermathecal pores, which occurred in each subdivision of the Japan Sea Division, is shown, the data being recapitulated also from the respective table from 6 to 9. In this table, the percentage number showed a decrease from the northern to the southern subdivision in IIAb, IIFa, IIFb and IIIGc, and perhaps in Ia. But on the other hand, it showed an increase southwards in IIAa, IIBb, IICa and IIFc, and perhaps in IIBa and IICa. In the others, the tendency to decrease or increase in not determinable,

even if the percentage number may show a decrease or an increase from Subdivision 5 to Subdivision 6 or 7 and then an increase or a decrease to Subdivision 8 respectively.

TABLE 16

Percentage numbers of the specimens in the three cases of the male pores in combination with the three cases of the spermathecal pores in each subdivision of the Japan Sea Division

Presence or absence of spermathecal pores		Presence or absence of male pores	Subdivision 5	Subdivision 6	Subdivision 7	Subdivision 8
I. Entire absence		a	57.0	49.7	39.6	43.0
		b	3.6	6.3	7.4	4.1
		c	16.5	16.9	19.8	19.1
II. Presence on both sides	A	a	1.8	2.1	2.8	4.6
		b	1.1	0.7	0.7	0.5
		c	1.1	0.7	0.7	0.9
	B	a	1.8	1.0	1.2	3.0
		b	0.4	0.7	0.7	0.9
		c	0.7	0.3	0.7	1.1
	C	a	1.1	1.7	2.3	3.4
		b	0.4	0.3	0.9	0.9
		c	0.0	0.7	0.7	0.7
	D	a	0.7	0.7	1.6	1.4
		b	0.0	0.3	0.7	0.2
		c	0.4	0.0	0.5	0.0
	E	a	0.7	0.7	0.9	0.5
		b	0.0	0.0	0.5	0.0
		c	0.4	0.3	0.7	0.0
	F	a	0.4	0.3	0.2	0.2
		b	0.4	0.3	0.2	0.0
		c	0.0	0.0	0.2	0.2
III. Presence on one side	G	a	3.9	5.2	7.4	4.6
		b	1.1	1.7	0.9	0.9
		c	1.4	1.4	1.2	0.9
	H	a	2.5	3.1	1.6	2.8
		b	0.4	0.7	0.5	0.9
		c	1.1	1.4	0.5	1.4
	I	a	0.7	1.7	2.9	2.3
		b	0.4	0.7	1.2	0.7
		c	0.4	0.3	0.7	0.7

Since the types of II and of III show different tendencies of change
of the variability, as in the case of the Pacific Division, Table 17 has
been prepared in order to see what change of the spermathecal pores
would show, as a whole, in II and in III, and, within the respective
limit, to know how the male pores would change in variability according
to each subdivision of the Japan Sea Division. The data given in this
table are the percentage numbers of the specimens summed up in the
corresponding places of the respective table from 6 to 9.

TABLE   17

Percentage numbers of the specimens summed up in whole case of
II and of III and in the respective cases of a, b, c in
each subdivision of the Japan Sea Division

Presence or absence of male pores		Subdivision 5	Subdivision 6	Subdivision 7	Subdivision 8
II		11.1	11.0	16.3	18.6
Entire absence	a	6.5	6.6	9.1	13.3
Presence on both sides	b	2.2	2.4	3.7	2.5
Presence on one side	c	2.5	2.1	3.5	3.0
III		11.8	16.2	16.7	15.2
Entire absence	a	7.2	10.0	11.9	9.7
Presence on both sides	b	1.8	3.1	2.6	2.6
Presence on one side	c	2.9	3.1	2.3	3.0

In the case of II, Table 17 shows that the percentage number of the
specimens with the spermathecal pores on both sides of the body tended
to increase from the northern to the southern subdivision, and that, within
this limit, the specimens without male pores tended to increase (a), those
with them on both sides showed a regular increase (b), and those with
one on one side showed no regularity (c).

In the case of III, Table 17 reveals that the percentage number of
the specimens with the spermathecal pore or pores on one side of the
body showed an increase from Subdivision 5 to Subdivision 7 and then
a decrease to Subdivision 8, and that, within this limit, the specimens
without male pores (a) and those with them on both sides (b) showed
an increase from Subdivision 5 to Subdivision 6 or 7 and then a decrease
to Subdivision 8. Those with a male pore on one side showed no regu-
larity (c).

TABLE 18

*Percentage numbers of the specimens, having spermathecal pores on
VI/VII (BC), and having those on VII/VIII (DF), in each
subdivision of the Japan Sea Division*

	Subdivision 5	Subdivision 6	Subdivision 7	Subdivision 8
BC	4.3	4.8	6.5	10.1
DF	1.8	1.7	3.5	0.2

Table 18 has been prepared in order to show the relation between
the numbers of the specimens with a pair of spermathecal pores on VI/VII
(BC) and those on VII/VIII (DF). The data given in this table are the
percentage numbers of the specimens summed up in the corresponding
places of the respective table from 6 to 9. This table reveals that BC
was constantly greater than DF, and that BC increased southwards,
while DF showed no regularity.

TABLE 19

*Percentage numbers of the specimens, in which the male pores are
entirely absent (a), present on both sides (b) and present on
one side of the body (c), being examined in each
subdivision of the Japan Sea Division*

Presence or absence of male pores		Subdivision 5	Subdivision 6	Subdivision 7	Subdivision 8
Entire absence	a	70.6	66.2	60.7	65.7
Presence on both sides	b	7.5	11.7	13.7	9.2
Presence on one side	c	21.9	22.1	25.6	25.1

Finally, Table 19 has been prepared in order to see the change of
variability in the male pores. The data are the percentage numbers of
the specimens summed up all a, all b and all c, respectively, in each
subdivision of the Japan Sea Division given in the respective table from
6 to 9.

COMPARISON OF THE RESULTS OBTAINED IN THE PACIFIC
AND THE JAPAN SEA DIVISIONS

I) In the general coincidence of the tendencies shown in both the
Pacific and the Japan Sea Divisions, the number of the specimens, in
which the spermathecal pores are entirely absent, shows a decrease

towards the south (Tables 10, 15). It is worthy of note that the number is invariably smaller in each subdivision of the Pacific Division than in the corresponding subdivision of the Japan Sea Division (Tables 10, 15).

a. In both divisions, the number of the specimens, in which the spermathecal and male pores are entirely absent, tends to a decrease in the southward direction (Tables 11, 16).

b. In both divisions, the number of the specimens, which lack the spermathecal pores, but which have a pair of male pores, shows an increase from the first[1] to the third[2] and then a decrease to the fourth[3] subdivision (Tables 11, 16).

c. In both divisions, the number of the specimens, which lack the spermathecal pores, but which have only one male pore, shows a similar change as before (Tables 11, 16).

In the case of a and of b, the number shows nearly the same value in both divisions, while in the case of c it is greater in the Japan Sea Division than in the Pacific Division (Tables 11, 16).

II) In general, the tendency in both divisions, with regard to the number of the specimens, having spermathecal pores on both sides of the body, shows an increase in the southward direction (Tables 12, 17). From this tendency, besides B and C in Table 10, which show a regular increase in the southward direction, we may judge that also A in Table 10 and A, B, and C in Table 15, at least, may be taken as cases of an increase in the southward direction, even if the tendencies shown by D, E, and F in both tables are indeterminable.

a. In both divisions, the number of the specimens, having spermathecal pores on both sides of the body, but lacking male pores, tends to an increase in the southward direction (Tables 12, 17).

b. In both divisions, the number of the specimens, having spermathecal and male pores on both sides of the body, shows an increase from the first to the second[4] or third and then a decrease to the fourth subdivision (Tables 12, 17).

c. In both divisions, the number of the specimens, having spermathecal

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[1] The first subdivision means Subdivision 1 in the Pacific Division or Subdivision 5 in the Japan Sea Division.

[2] The third subdivision means Subdivision 3 in the Pacific Division or Subdivision 7 in the Japan Sea Division.

[3] The fourth subdivision means Subdivision 4 in the Pacific Division or Subdivision 8 in the Japan Sea Division.

[4] The second subdivision means Subdivision 2 in the Pacific Division or Subdivision 6 in the Japan Sea Division.

pores on both sides and a male pore on one side of the body, tends to increase from the first to the third and then to decrease to the fourth subdivision (Tables 12, 17).

From the generalizations, above-mentioned, we may conclude in relation to every type as follows:

A. In both divisions, the number of the specimens, having two pairs of spermathecal pores, tends to an increase in the southward direction. The number is distinctly greater in the Pacific Division than in the Japan Sea Division (Tables 10, 15).

a. In both divisions, the number of the specimens, having the four spermathecal pores, but lacking male pores, tends to an increase in the southward direction. The number is greater in the Pacific Division than in the Japan Sea Division (Tables 11, 16).

b. In both divisions, the number of the specimens, having the four spermathecal and a pair of male pores, tends to a decrease in the southward direction (Tables 11, 16).

c. In both divisions, the number of the specimens, having the four spermathecal and one male pores, tends to a decrease in the southward direction (Tables 11, 16).

B. In both divisions, the number of the specimens, having a pair of spermathecal pores on VI/VII, tends to an increase in the southward direction. The number is greater in the Pacific Division than in the Japan Sea Division (Tables. 10, 15).

a. In both divisions, the number of the specimens, having the two spermathecal pores, but lacking male pores, tends to an increase in the southward direction. The number is greater in the Pacific Division than in the Japan Sea Division (Tables 11, 16).

b. In the Pacific Division, the number of the specimens, having a pair of spermathecal and of male pores, shows an increase from the first to the second, and then a decrease to the fourth subdivision (Table 11), while, in the Japan Sea Division, it shows an increase in the southward direction (Table 16).

c. In the Pacific Division, the number of the specimens, having the two spermathecal and one male pores, shows an increase from the first to the second, and then a decrease to the fourth subdivision (Table 11), while, in the Japan Sea Division, it tends to an increase in the southward direction (Table 16).

C. In both divisions, the number of the specimens, having a pair of spermathecal pores on VI/VII and one on one side of VII/VIII, shows

an increase in the southward direction.   The number is greater in the Pacific Division than in the Japan Sea Division (Tables 10, 15).

a.   In both divisions, the number of the specimens, having the three spermathecal pores, but lacking male pores, shows an increase in the southward direction.   The number is greater in the Pacific Division than in the Japan Sea Division (Tables 11, 16).

b.   In both divisions, the number of the specimens, having the three spermathecal pores and a pair of male pores, tends to an increase in the southward direction.   The number is greater in the Pacific Division than in the Japan Sea Division (Tables 11, 16).

c.   In both divisions, the number of the specimens, having the three spermathecal pores and one male pore, shows an increase in the southward direction.   The number is greater in the Pacific Division than in the Japan Sea Division (Tables 11, 16).

D.   In the Pacific Division, the number of the specimens, having one spermathecal pore on VI/VII and two spermathecal pores on VII/VIII, shows a decrease in the southward direction (Table 10), while, in the Japan Sea Division, it tends to an increase from the first to the third and then to a decrease to the fourth subdivision (Table 15).

III)   In general, the number of the specimens with spermathecal pore or pores only on one side of the body shows an increase in the southward direction in the Pacific Division, while it shows an increase from the first to the third and then a decrease to the fourth subdivision in the Japan Sea Division (Tables 12, 17).

a.   In the Pacific Division, the number of the specimens, having the spermathecal pore or pores on one side, but lacking male pores, shows a decrease from the first to the second, and then an increase to the fourth subdivision, while, in the Japan Sea Division, it shows an increase from the first to the third, and then a decrease to the fourth subdivision (Tables 12, 17).

b.   In both divisions, the number of the specimens, having one or two spermathecal pores on one side and a pair of male pores, shows an increase from the first to the second, and then a decrease to the fourth subdivision (Tables 12, 17).

c.   In the Pacific Division, the number of the specimens, having the spermathecal pore or pores on one side and a male pore on one side, shows an increase from the first to the second, and then a decrease to the fourth subdivision, while, in the Japan Sea Division, it shows no regularity (Tables 12, 17).

G. In the Pacific Division, the number of the specimens, having one spermathecal pore on VI/VII, shows an increase in the southward direction (Table 10), while, in the Japan Sea Division, it shows an increase from the first to the third, and then a decrease to the fourth subdivision (Table 15).

a. In the Pacific Division, the number of the specimens, having the one spermathecal pore, but lacking male pores, shows an increase in the southward direction (Table 11), while, in the Japan Sea Division, it shows an increase from the first to the third, and then a decrease to the fourth subdivision (Table 16).

b. In both divisions, the number of the specimens, having the one spermathecal pore and a pair of male pores, shows an increase from the first to the second, and then a decrease to the fourth subdivision (Tables 11, 16).

c. In the Pacific Division, the number of the specimens, having the one spermathecal and only one male pores, shows an increase from the first to the second, and then a decrease to the fourth subdivision (Table 11), while, in the Japan Sea Division, it shows a decrease in the southward direction (Table 16).

H. In the Pacific Division, the number of the specimens, having one spermathecal pore only on VII/VIII, shows an increase in the southward direction (Table 10), while, in the Japan Sea Division, it shows no regularity (Table 15).

I. In both divisions, the number of the specimens, having two spermathecal pores only on the same side of the body, tends to an increase from the first to the third, and then a decrease to the fourth subdivision (Tables 10, 15).

IV) In each division, the number of the specimens, which have a pair of spermathecal pores on VI/VII (B) is invariably greater than the number of the specimens which have a pair of these on VII/VIII (F). The former number found in each subdivision of the Pacific Division is invariably greater than the corresponding number found in that of the Japan Sea Division, while the latter remains nearly equal in both divisions (Tables 10, 15).

In each division, the sum of the numbers of the specimens, having a pair of spermathecal pores on VI/VII (BC), is always greater than that, having a pair of those on VII/VIII (DF). The former sum obtained in each subdivision of the Pacific Division is invariably greater than the corresponding sum obtained in that of the Japan Sea Division, while the

latter also remains nearly equal in both divisions. Moreover, in both divisions, BC shows an increase in the southward direction, while DF tends to a decrease in the southward direction (Tables 13, 18).

In each division, the number of the specimens, possessing one spermathecal pore on VI/VII (G) is greater than that, possessing one spermathecal pore on VII/VIII (H) (Tables 10, 15).

From the above-mentioned, repeated evidences along the same line as to the occupation of spermathecal pores, it is assured that VI/VII is more dominant in frequency than VII/VIII is, and that BC as well as B is greater in the Pacific Division than in the Japan Sea Division.

V) In the comparison of Tables 14 and 19, the following statements may be made : —

a. In both the Pacific and the Japan Sea Divisions, the number of the specimens, having no male pore, shows a decrease from the first to the third, and then an increase to the fourth subdivision. The number appears to be greater in the Pacific Division than in the Japan Sea Division.

b. In both divisions, the number of the specimens, having a pair of male pores on both sides of the body, shows an increase from the first to the third, and then a decrease to the fourth subdivision. The number is greater in the Pacific Division than in the Japan Sea Division.

c. In both divisions, the number of the specimens, having a male pore on one side of the body, shows an increase from the first to the third, and then a decrease to the fourth subdivision. The number is smaller in the Pacific Division than in the Japan Sea Division.

THE TEMPERATURE AND RAINFALL IN THE ÔU REGION

1) The average temperature in winter, especially in February.

Nearly the whole northern area of the Ôu Region is subject to a temperature below freezing point, while its southern areas near the Pacific Ocean and the Japan Sea are subject to a temperature above zero.

a) The Pacific Division.

Subdivision 1. In the eastern half of this subdivision, the temperature is above freezing point, while, in the western half, including the Shimokita Peninsula, and also in the southernmost area of Aomori Prefecture, the temperature is 0°C – –4°C.

Subdivision 2. In the eastern lesser area along the coast of the Pacific Ocean, the temperature is above freezing point. The western

larger area, however, is subject to severe cold, especially in the central portion which is an area of considerable size. The temperature here is −4°C − −7.6°C.

Subdivision 3. In its eastern larger area along the Pacific coast, the temperature is above zero, and even in the coldest part forming the western lesser area, it drops only to −4.5°C. In the south-eastern corner of Miyagi Prefecture, the temperature is above 4°C.

Subdivision 4. The area having a temperature below zero is restricted to the western side of this subdivision. In the eastern larger area, the temperature is 0°C - 5 5°C, rising in its south-eastern small area to 5.8°C.

b) The Japan Sea Division.

Subdivision 5. In the eastern larger area the temperature is 0°C −3°C, while, in the western lesser area, it rises slightly above freezing point.

Subdivision 6. In the eastern larger area the temperature is 0°C −1°C, and, in the western lesser area along the Japan Sea coast, it is 0°C - 2°C.

Subdivision 7. In the eastern larger area the temperature is 0°C − −4°C, and in the western lesser area along the coast of the Japan Sea as well as on the border of Niigata Prefecture, it is 0°C − 2°C.

Subdivision 8. In the north-eastern corner and in the southern larger area the temperature is below freezing point, but in the remaining areas it is 0°C−1.4°C.

2) The average temperature in summer, especially in August.

The isothermal line of 24°C progresses southwards following approximately the Ôu mountain range, and the area east of the mountains shows a temperature below 24°C, while the area west of them shows a temperature above 24°C.

a) The Pacific Division.

Subdivision 1. In the western lesser area the temperature is below 24°C, while in the eastern larger area it is 24°C. In the southern small area near Iwate Prefecture, it rises to 26°C.

Subdivision 2. The whole area of this subdivision shows 24°C, with the exception of the northern portion − a considerably wide area - which shows 20°C - 23.7°C.

Subdivision 3. Almost the whole area of this subdivision shows a temperature above 24°C, except the south-western corner which shows 22°C.

Subdivision 4. In this subdivision the temperature is 24°C − 27.7°C, with the exception of the north-western corner which shows a temperature below 22°C.

b) The Japan Sea Division.

Subdivision 5. This subdivision shows 24°C – 26°C, with the exception of the eastern small area which shows 22°C – 23.7°C.

Subdivision 6. This subdivision shows 24°C – 27.7°C, but a small area on the coast of the south-western part shows 28°C.

Subdivision 7. This subdivision shows 24°C – 25°C, but in the south-western corner, the temperature is 26°C.

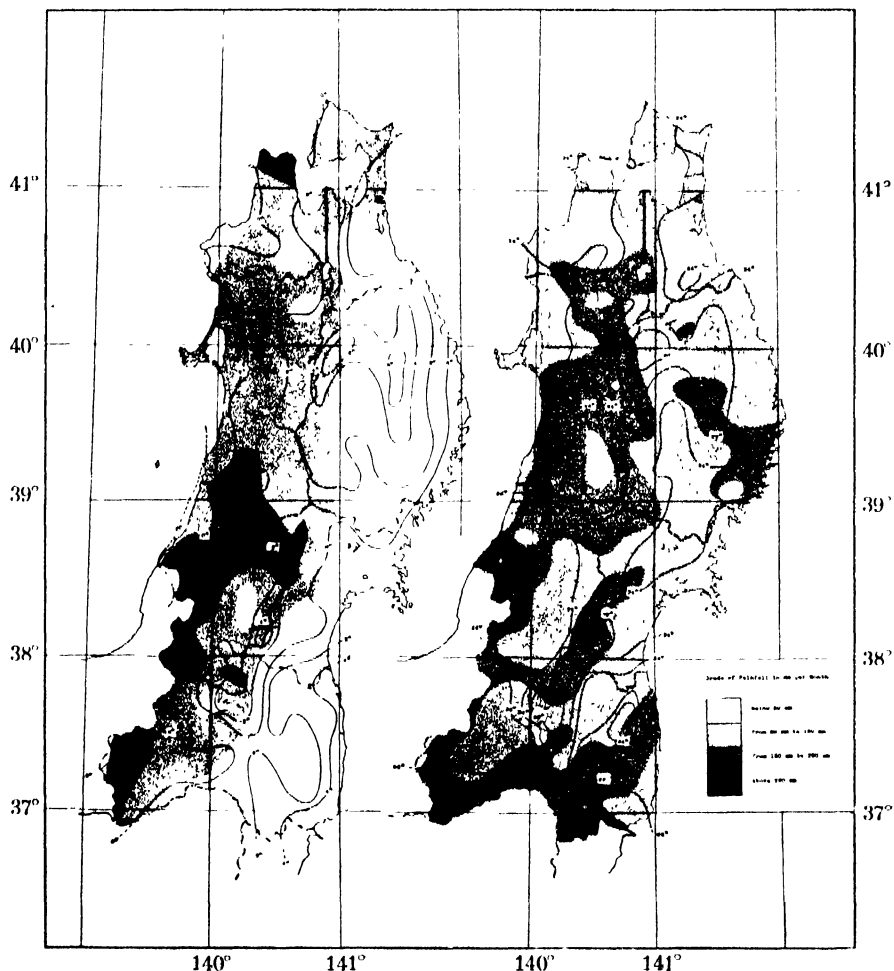Subdivision 8. This subdivision shows 25.9°C – 27.1°C.

Fig. 5. A map of the Ôu Region, showing the distribution of average temperature and of average rainfall in February (left) and in August (right). This is a map modified from that presented to me, owing to the good offices of the Meteorological Observatory in Sendai.

3) The average rainfall in winter, especially in February.

The rainfall of the Pacific Division is less than 80 mm per month and that of the Japan Sea Division is more than 80 mm.

a) The Pacific Division.

Subdivision 1. The south-eastern larger area shows a rainfall of less than 80 mm, while the northern larger and western smaller areas show 80 mm–152 mm.

Subdivision 2. The eastern sea-coast area and the southern larger area show a rainfall of less than 80 mm, while the western lesser area shows 80 mm–199 mm.

Subdivision 3. The eastern larger area shows a rainfall of below 80 mm, while the western lesser area shows 80 mm–210 mm.

Subdivision 4. The eastern larger area shows a rainfall of less than 80 mm, even though it contains two or three small areas near the Pacific Ocean in which the rainfall surpasses 80 mm. The western lesser area shows 80 mm–182 mm.

b) The Japan Sea Division.

Subdivision 5. Nearly the whole area of this subdivision shows a rainfall of more than 80 mm, in places 120 mm, and the northern area shows 266 mm.

Subdivision 6. Nearly the whole area of this subdivision shows a rainfall of more than 80 mm, in places 120 mm–144 mm, and even in the south-western corner the exceptional rainfall reaches 191 mm.

Subdivision 7. Nearly the whole area of this subdivision shows a rainfall of more than 80 mm, but the northern larger area shows as much as 234 mm, and the western small area near Niigata Prefecture as much as 404 mm.

Subdivision 8. The eastern larger area shows 80 mm–149 mm and the western lesser area 160 mm–184 mm.

4) The average rainfall in summer, especially in August.

In this season, the rainfall increases over the Ôu Region.

a) The Pacific Division.

Subdivision 1. The whole area of this subdivision shows a rainfall of 80 mm–160 mm.

Subdivision 2. The northern and the southern areas show a rainfall of 80 mm–160 mm, and the central, the western and the south-eastern areas 160 mm–260 mm.

Subdivision 3. The eastern larger area shows 80 mm–160 mm, and the western lesser area 160 mm–260 mm.

Subdivision 4. The northern and the south-eastern areas show 80 mm–160 mm, and the north-eastern, the southern and the western areas 160 mm–260 mm.

b) The Japan Sea Division.

Subdivision 5. The whole area of this subdivision shows 80 mm–160 mm, with the exception of the northern and the southern areas which show 160 mm–225 mm.

Subdivision 6. The whole area of this subdivision shows 160 mm–260 mm, with the exception of the north-western area which shows 80 mm–160 mm.

Subdivision 7. The central area shows 80 mm–160 mm and the northern, the western, the southern and the eastern areas show 160 mm–260 mm.

Subdivision 8. The north-eastern area shows 80 mm–160 mm and the south-western area 160 mm–260 mm.

GENERAL CONSIDERATION

1) In the present paper the study of the variability of the spermathecal pores was prompted in the first instance by the intense interect I took in this subject, being aware that up to this time the positions and numbers of these pores were generally considered to be invariable, this invariability furthermore being considered a characteristic, taxonomically, of *Pheretima irregularis*. My study of the spermathecal pores was however carried out before that of the male pores, but there is no special reason, for maintaining this order of study. As a matter of fact the results of study adopting this order, i. e. the spermathecal pores first and then the male pores, are nearly identical with those found in adopting the reverse order i. e. the male pores first and then the spermathecal pores. It is noticeable that more irregularities are found in the latter order than in the former.

2) In an inspection of the change of the variability in the genital pores in *Pheretima irregularis* allied to an inspection of the temperature and rainfall in the Ôu Region, there were found the following phenomena.

i) In general, the temperature in the Ôu Region rises in passing from the northern to the southern subdivision. With this tendency, in both divisions, the specimens having no spermathecal pores (I), those having none of male and spermathecal pores (Ia), those having two pairs of spermathecal and a pair of male pores (IIAb), those having the four spermathecal pores and one male pore (IIAc), those having one sperma-

thecal pore on VI/VII and two spermathecal pores on VII/VIII (IID), and those having one spermathecal pore on VI/VII and one male pore (IIIGc) tend to decrease in number towards the South. On the other hand, the specimens having spermathecal pores on both sides of the body (II), those having the spermathecal pores on both sides but lacking male pores (IIa), those having two pairs of spermathecal pores (IIA), those having two pairs of spermathecal pores but lacking male pores (IIAa), those having a pair of spermathecal pores on VI/VII (IIB), those having the pair of spermathecal pores but lacking male pores (IIBa), those having the pair of spermathecal pores and a pair of male pores (IIBb), those having a pair of spermathecal pores on VI/VII and one spermathecal pore on one side of VII/VIII (IIC), those having the three spermathecal pores but lacking male pores (IICa), those having the three spermathecal pores and a pair of male pores (IICb), those having the three spermathecal pores and one male pore (IICc), in the Pacific Division, those having one or two spermathecal pores only on one side of the body (III), those having one spermathecal pore on VI/VII (IIIG), those having the one spermathecal pore but lacking male pores (IIIGa), those having one spermathecal pore on VII/VIII (IIIH), in the Japan Sea Division, those having a pair of spermathecal pores on VI/VII and a pair of male pores (IIBb), and those having the two spermathecal pores and one male pore (IIBc) increase in number towards the South.

From the statements above-mentioned, it is noticeable that the difference of temperature to some extent is the main factor causing the decrease or increase in the number of the pores as observed in the specimens, which were examined in order to discover the respective variations of the genital pores.

ii) Moreover, the specimens having no spermathecal pores but having a pair of male pores (Ib), those having no spermathecal pores but having one male pore (Ic), those having spermathecal and male pores on both sides of the body (IIb), those having spermathecal pores on both sides and a male pore on one side of the body (IIc), those having one or two spermathecal pores on one side and a pair of male pores (IIIb), those having one spermathecal pore on VI/VII and a pair of male pores (IIIGb), those having two spermathecal pores on the same side of the body (III I), in the Pacific Division, those having a pair of spermathecal pores on VI/VII and a pair of male pores (IIBb), those having the two spermathecal pores and one male pore (IIBc), those having one or two spermathecal pores on one side and a male pore (IIIc), those having one spermathecal pore

on VI/VII and one male pore (IIIGc), in the Japan Sea Division, those having one spermathecal pore on VI/VII and two spermathecal pores on VII/VIII (IID), those having one or two spermathecal pores on one side (III), those having one spermathecal pore on VI/VII (IIIG), and those having the one spermathecal pore but lacking male pores (IIIGa), tend to increase in number from the first to the second or third and then to decrease to the fourth subdivision. On the contrary, the specimens having one or two spermathecal pores on one side but lacking male pores (IIIa) tend to decrease in number from the first to the second or third and then to increase to the fourth subdivision.

The former case of increase and then of decrease in number may be taken as proving that the environmental factors reached the most favourable condition for producing the respective variations in the second or third subdivision. But the latter case of decrease and then of increase need not be taken as proving that the environmental factors the least favourable condition in the second or third subdivision, because in considering temperature alone in the region concerned, better conditions cannot exist in the direct northern or southern neighbourhoods. It may rather be understood as a case of an increase or a decrease towards the South.

iii) In the Ôu Region, the Pacific Division is clearly distinguished from the Japan Sea Division by a lower temperature and less rainfall. With these differences, the specimens having two pairs of spermathecal pores (IIA), those having two pairs of spermathecal pores but lacking male pores (IIAa), those having a pair of spermathecal pores on VI/VII (IIB), those having a pair of spermathecal pores but lacking male pores (IIBa), those having a pair of spermathecal pores on VI/VII and one spermathecal pore on VII/VIII (IIC), those having the three spermathecal pores but lacking male pores (IICa), those having the three spermathecal pores and a pair of male pores (IICb), and those having the three spermathecal pores and one male pore (IICc) are greater in number in the Pacific Division than in the Japan Sea Division. On the other hand, the specimens having no spermathecal pores (I), and those having no spermathecal pores but one male pore (Ic) are smaller in number in the Pacific Division than in the Japan Sea Division. And the specimens having none of either spermathecal or male pores (Ia), and those having no spermathecal pores but a pair of male pores (Ib) show nearly the same number in both the Pacific and the Japan Sea Divisions.

From the conclusion in 2 i) that the temperature is the main factor in producing the variations, it is evident that the Japan Sea Division,

which has a higher temperature, ought to produce specimens with either more or less differences than those of the Pacific Division, which has a lower temperature. The smaller number in IIA, IIB and IIC found in the Japan Sea Division may be considered to prove that the production of the variations is obstructed, and that the greater number in I and Ic found in the Japan Sea Division to prove that the production of the variations is strengthened, and, in the case of the similarity of numbers in Ia and Ib found in both divisions, the production of the variations is not affected even by an excessive rainfall.

3) The number of the specimens having the spermathecal pores on both sides of the body coincides in an increase in the southward direction with that having a pair of male pores (Tables 12, 15, 17, 19), and the number of the specimens having one or two spermathecal pores on one side of the body coincides also in an increase in the southward direction with that having one male pore (Tables 12, 15, 17, 19). But the presence or absence of spermathecal pores, and that of male pores show the following discordances:

The number of the specimens having no spermathecal pores shows a decrease in the southward direction, while that having no male pores shows a decrease from the first to the third and then an increase to the fourth subdivision (Tables 10, 12, 14, 19), and the former is smaller in the Pacific Division, while the latter is smaller in the Japan Sea Division (Tables 10, 14, 15, 19). Moreover, in the Pacific Division, the former is smaller than the latter (Tables 10, 14), while, in the Japan Sea Division, the former is larger than the latter (Tables 15, 19).

The above contradictions suggest that there cannot exist any correlation between the presence or absence of spermathecal pores and that of male pores.

4) From the comparison of BC and DF (Tables 13, 18), of B and F (Tables 10, 15) and of G and H (Tables 10, 15), it seems to suggest that the specimens having spermathecal pores on the intersegmental furrow VI/VII represent the fundamental type of *Pheretima irregularis*.

5) Several questions arise there in connection with the present study. Most of them can be solved experimentally and statistically, some morphologically and some physiologically, and many further questions may follow in due course. To these questions, however, the answers are postponed.

SUMMARY

1. The present study is limited to the specimens of *Pheretima irregularis* obtained in the Ôu Region, Japan.

2. The specimens, in which male and spermathecal pores are entirely absent, - are dominant in number in comparison with the other types (Tables 2–9, 10, 11, 15, 16).

3. The specimens, in which male pores are absent, are greater in number than those, in which spermathecal pores are absent (Tables 10, 14, 15, 19).

4. Among the specimens having spermathecal pores on both sides of the body, those having two pairs on VI/VII and VII/VIII (IIA), those having one pairs on VI/VII (IIB), and those having one pair on VI/VII and one on one side of VII/VIII (IIC) are greater in number in comparison with the other types (Tables 10, 15).

5. Among the specimens having spermathecal pores on one side of the body, those having one on VI/VII (IIIG) are greater in number in comparison with the other types (Tables 10, 15).

6. The average temperature and rainfall in winter and summer in the Ôu Region is explained in order to elucidate the origin of distribution of each variation in *Pheretima irregularis.*

7. The specimens having no spermathecal pores (I), those having two pairs of spermathecal and a pair of male pores (IIAb), etc. tend to decrease in number in the southward direction, because of their adaptation to a comparatively low temperature.

8. The specimens having spermathecal pores on both sides of the body (II), those having two pairs of spermathecal pores (IIA), those having a pair of spermathecal pores on VI/VII (IIB), those having a pair of spermathecal pores on VI/VII and one spermathecal pore on VII/VIII (IIC), etc. tend to increase in number in the southward direction, because of their adaptation to a comparatively high temperature.

9. The specimens having two pairs of spermathecal pores (IIA), those having a pair of spermathecal pores on VI/VII (IIB), those having a pair of spermathecal pores on VI/VII and one spermathecal pore on VII/VIII (IIC), etc. are smaller in number in the Japan Sea Division than in the Pacific Division, because of the obstruction caused by the rainfall, which is greater in the former than in the latter.

10. The specimens having no spermathecal pores (I), etc. are greater in number in the Japan Sea Division than in the Pacific Division, because

of the enrichment caused by the greater rainfall.

11. The presence or absence of spermathecal pores is independent of that of male pores.

12. The fundamental type of *Pheretima irregularis* seems to possess spermathecal pores on VI/VII.

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FRESH-WATER SPONGES OBTAINED IN SOUTH SAGHALIN

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(With Plates V–VII and 7 text-figures)
(Received April 8, 1939)

The fauna of the fresh-water sponges of South Saghalin has remained entirely unknown till the present time.

In the Autumn of 1935, 1 made a trip to the above mentioned district and tried to collect sponges of that group in many lakes, ponds and streams.

Although the lakes and ponds distributed in the said district are great in number, most of them seem to be not favourable in condition for the luxuriant existence of fresh-water sponges, for the following reasons.

First, it is clear that the duration of life of the sponge in this district is shorter than of those in the southern parts of Japan as the temperature of the lakes and ponds is generally lower and moreover the surface of the water is covered with ice for many months during the cold winter. Secondly, many of the relatively small lakes and ponds that are distributed in the northern parts of this district, are full of water of a reddish or brownish colour, such is found in "Tundra", and are acidic in various degrees; thus they are not favourable for the existence of sponges. Thirdly, almost all of the larger lakes such as Lake Taraika, L. Tonnai, L. Raichishi, L. Tôbuchi, etc., are filled with salt water of various percentages and thus the fresh-water sponges are not able to grow in it.

On account of the above mentioned reasons, it is natural that the distribution of the fresh-water sponges in this district is limited to only a small number of localities.

Thus I was able to obtain only three species, together with one variety, of fresh-water sponges in all, which are shown in the following list.

1. *Spongilla lacustris* (L.)
2. *Spongilla fragilis* Leidy
3. *Ephydatia mülleri* (Lieberkühn)
4. *Heteromeyenia baileyi* var. *petri* (Lauterborn)

Some of the specimens representing these forms are more or less different from the specimens obtained from other parts of Japan. I

should like also to deal with these differences in the present paper in more detail.

I wish here to express my hearty thanks to Professor Dr. SANJI HôZAWA who has kindly directed me during the course of my investigation.

1. Spongilla lacustris (L.)
(Pls. V, VI, Figs. 1-13; Text-figs. 1, 2, 3, 4)

This sponge is found in both stagnant and running water being attached to the surface of submerged wood, logs, roots, trunks of trees, twigs, water plants, the piles of piers, the shells of molluscs and to other solid objects found at a depth of 0.5–5 metres or more.

The external form of the sponge (Pls. V, VI, Figs. 1–13) is variable under different ecological conditions. Especially when the current is not
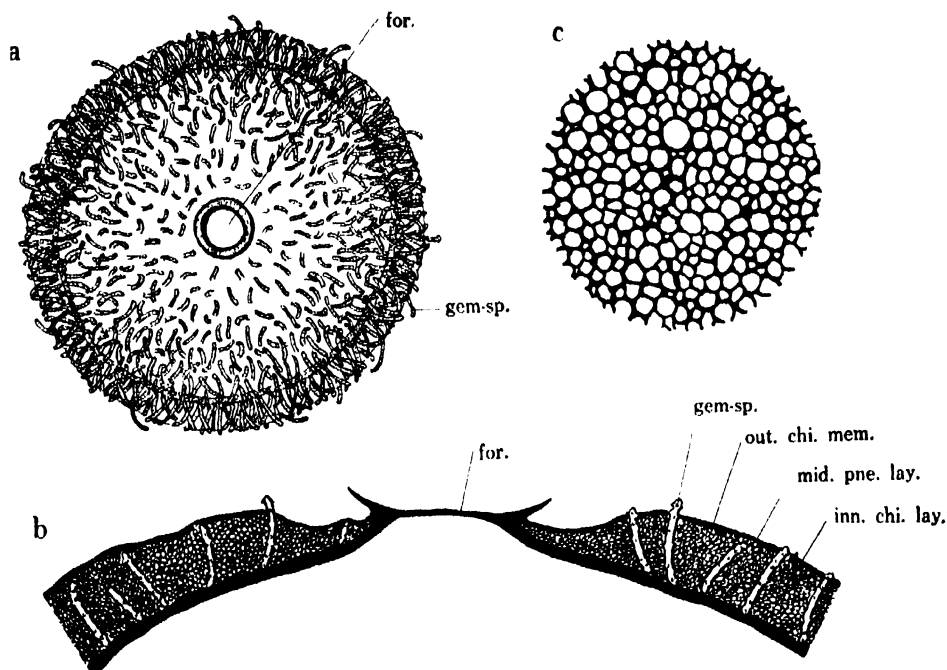
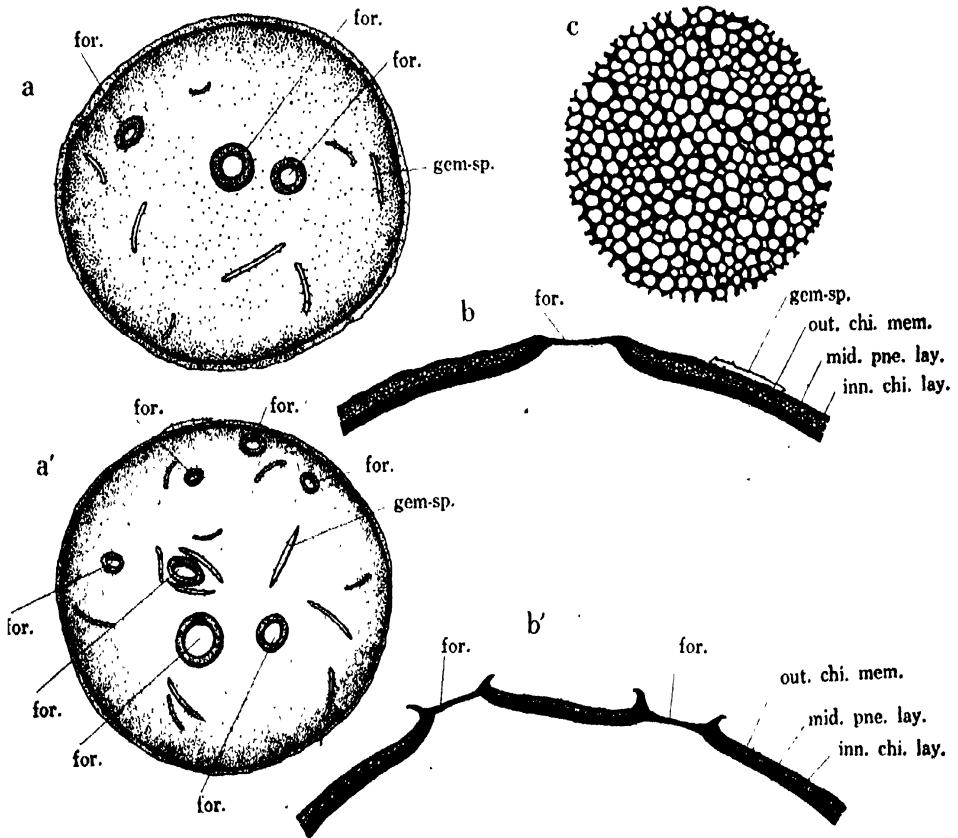Text-fig. 1. *Spongilla lacustris* (L.) forma *typica*. a, Gemmule, showing a foramen (=foraminal aperture) in the center. b, Sagittal section of the foramen. c, A part of the pneumatic layer. (a ×80; b ×240; c ×800). Specimen from Uraike. *for.*, foramen; *gem-sp.*, gemmule-spicule; *inn. chi. lay.*, inner chitinous layer; *mid. pne. lay.*, middle pneumatic layer; *out. chi. mem.*, outer chitinous membrane.

very rapid, the sponge generally forms a thin layer or a crust, from which ordinarily many cylindrical or flattened, long or short finger-like or thread-like projections arise. Sometimes these projections may branch and anastomose with one another to form a complex network.

They are in most cases soft and fragile in consistence but sometimes they are comparatively firm. Usually the external surface is covered with a well-developed dermal membrane.

The oscula are conspicuous being of a relatively large size in the cases of well-grown specimens, but they are mostly obscure in the cases

Text-fig. 2. *Spongilla lacustris* (L.) forma *polyporis*. a, a′, Gemmule, several foraminal apertures are shown. b, b′, Sagittal section of the apertures. c, A part of the pneumatic layer. (a, a′ ×80; b, b′ ×240; c ×800). a, b, c Specimen from Lake Shòsen. a′, b′ Specimen from Marunuma. *for.*, foraminal aperture; *gem-sp.*, gemmule-spicule; *inn. chi. lay.*, inner chitinous layer; *mid. pne. lay.*, middle pneumatic layer; *out. chi. mem.*, outer chitinous membrane.

of thin and small specimens.   The pores found on the outer surface are
great in number but are very small in size.

The colour of the sponge in life is very variable being bright-green,
green, yellow, yellow-green, orange, cream, white, or grey, etc. according
to the amount of sun-light it received.

Gemmules (Text-figs. 1, 2).   The gemmules are formed abundantly
throughout the whole sponge body.   Each gemmule is spherical or sub-
spherical in shape (Text-figs. 1, a ; 2, a, a') and yellow, orange or brown in
colour and is generally covered with a thick or thin pneumatic coat
which bears gemmule-spicules arranged radially or tangentially.   This coat
is composed of the inner chitinous layer, the middle pneumatic layer which
is either thick or very thin, and the outer chitinous membrane.   The middle
pneumatic layer consists of small granular air chambers (Text-figs. 1, c ;
2, c).

Ordinarily each gemmule has a single foramen but some have from 2
to 7 or more of these (Text-fig. 2, a, a').   Generally the foramen is pro-
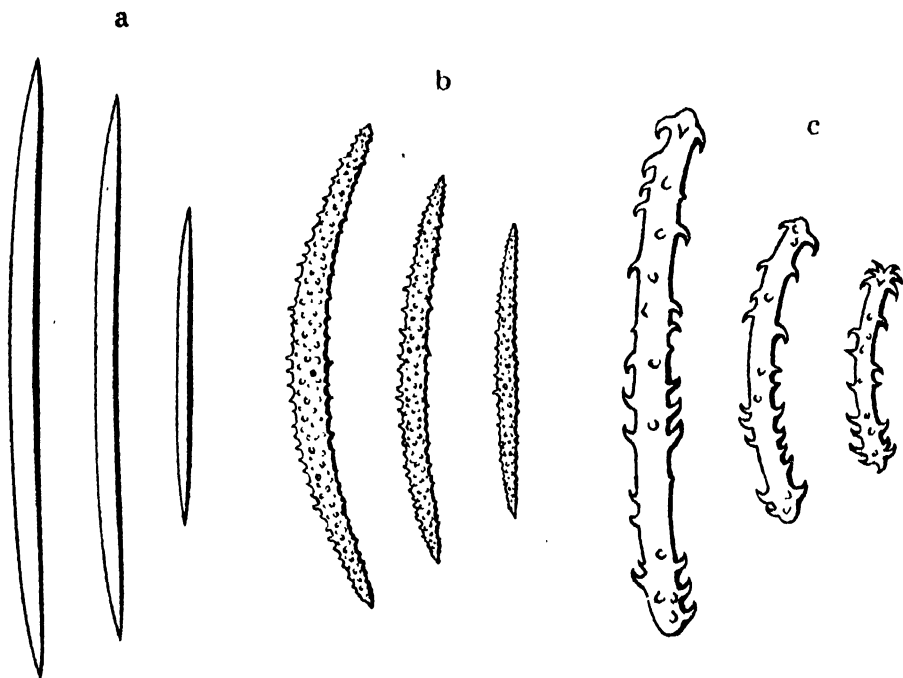
Text-fig. 3. *Spongilla lacustris* (L.) forma *typica*. a, Skeleton-spicules. b, Flesh-
spicules. c, Gemmule-spicules. (a ×240; b, c ×800). Specimen from Fujinuma.

tected by a chitinous cup-like or dish-shaped structure (Text-figs. 1, b ; 2, b'), but sometimes it has none of these structures except for a chitinous operculum placed at the orifice (Text-fig. 2, b).
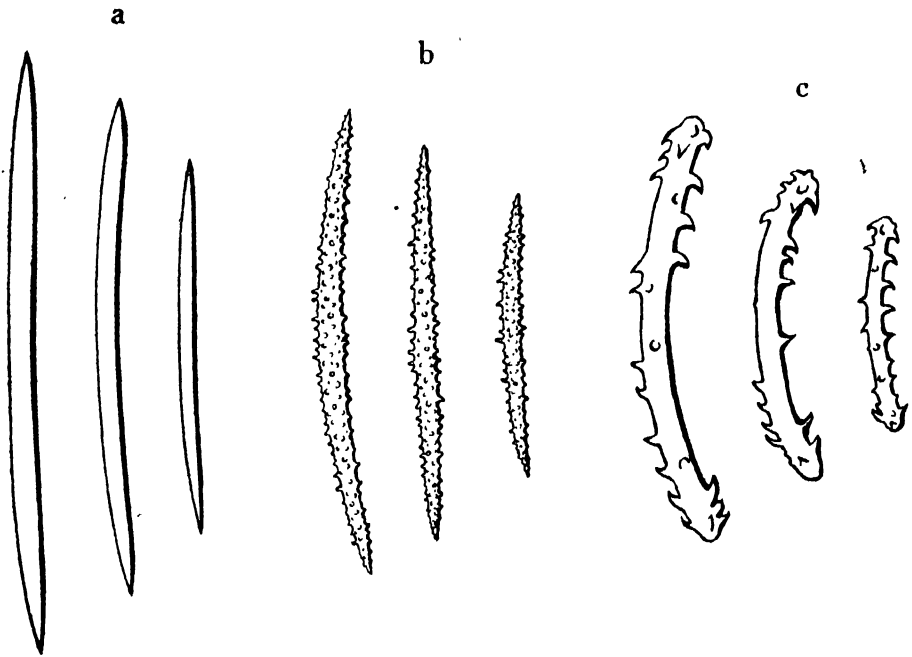
Text-fig. 4. *Spongilla lacustris* (L.) forma *polyporis.* a, Skeleton-spicules. b, Flesh-spicules. c, Gemmule-spicules. (a ×240; b, c ×800). Specimen from Fujinuma.

Spicules (Text-figs. 3, 4). The skeleton-spicules (Text-figs. 3, a ; 4, a) are slender, straight or slightly curved, gradually and very sharply pointed at the extremities. Their surface is entirely smooth.

The flesh-spicules (Text-figs. 3, b ; 4, b) are variable in number. They are small, straight or curved, gradually tapering at both ends and are densely covered with minute spines.

The gemmule-spicules (Text-figs. 3, c ; 4, c) are very variable not only in size and shape but also in number. They are long or short, slightly or strongly curved, being provided with a small number of straight or curved spines. But sometimes they are nearly smooth. Their ends are rounded or bluntly pointed.

Localities. Uraike No. 15 near Lake Taraika, Province of Shikuka ; Bakkonuma near Lake Raichishi, Province of Ushiro ; Fujinuma near

Chinnai, Hyôtanike near Chinnai, Lake Shôsen near Chinnai, Province of Kushunnai; Bakenuma near Lake Tôro, Province of Nayoshi; Marunuma near Randomari Province of Maoka; Tôbako near Lake Tonnai, the River Icchian near Lake Tonnai, Kajinuma near Lake Tonnai, Province of Tonnai.

Measurements.

Specimen from	Length	Diameter measured at the thickest portion	
Uraike:	(average)		(average)
Skeleton-spicules	200 -310 μ (262.4 μ)	6 -12.0 μ	(8.84 μ)
Flesh-spicules	45- 82 μ (63.6 μ)	2.5- 3.5 μ	(3.15 μ)
Gemmule-spicules	28- 98 μ (53.68 μ)	3 - 5.0 μ	(4.02 μ)
Bakkonuma:			
Skeleton-spicules	180 360 μ (296.0 μ)	8 9 μ	(15.06 μ)
Flesh-spicules	40- 87 μ (63.94 μ)	4 - 6 μ	(4.82 μ)
Gemmule-spicules	45-120 μ (85.04 μ)	3 - 7 μ	(4.98 μ)
Fujinuma (a):			
Skeleton-spicules	180-350 μ (303.2 μ)	6 -12 μ	(9.56 μ)
Flesh-spicules	50- 82 μ (64.54 μ)	3 - 5 μ	(3.44 μ)
Gemmule-spicules	33- 90 μ (50.34 μ)	2.5 5 μ	(3.26 μ)
Fujinuma (b):			
Skeleton-spicules	210-340 μ (277.8 μ)	7 -12 μ	(9.67 μ)
Flesh-spicules	47- 78 μ (63.52 μ)	2.5- 4 μ	(3.16 μ)
Gemmule-spicules	37- 72 μ (51.58 μ)	2.5 4 μ	(3.14 μ)
Shôsenko:			
Skeleton-spicules	220-360 μ (304.3 μ)	13 -20 μ	(17.54 μ)
Flesh-spicules	45- 89 μ (66.68 μ)	4 - 6 μ	(5.04 μ)
Gemmule-spicules	40-115 μ (75.76 μ)	4 7 μ	(5.14 μ)
Bakenuma:			
Skeleton-spicules	200-380 μ (299.4 μ)	10 -17 μ	(13.35 μ)
Flesh-spicules	45- 85 μ (59.58 μ)	3 - 5 μ	(3.92 μ)
Gemmule-spicules	35- 71 μ (55.16 μ)	3 · 5 μ	(3.79 μ)
Marunuma (a):			
Skeleton-spicules	160-340 μ (280.5 μ)	6 -10 μ	(7.67 μ)
Flesh-spicules	51- 83 μ (71.36 μ)	3 - 4 μ	(3.54 μ)
Gemmule-spicules	36- 71 μ (52.06 μ)	1 - 2 μ	(1.50 μ)
Marunuma (b):			
Skeleton-spicules	180 370 μ (292.0 μ)	8 20 μ	(14.66 μ)
Flesh-spicules	48-103 μ (82.7 μ)	3.5 7 μ	(5.22 μ)
Gemmule-spicules	65-135 μ (90.4 μ)	4 - 8 μ	(5.85 μ)

Specimen from	Diameter of gemmules		Thickness of pneumatic covering of gemmules	
		(average)		(average)
Uraike:	600-850 μ	(699.2 μ)	50-65 μ	(56.0 μ)
Bakkonuma:	300-660 μ	(519.4 μ)	9-12 μ	(10.0 μ)
Fujinuma (a):	340 630 μ	(488.6 μ)	30-50 μ	(40.5 μ)
Fujinuma (b):	370-810 μ	(600.2 μ)	12 18 μ	(15.0 μ)
L. Shôsen:	450-770 μ	(606.1 μ)	12-20 μ	(15.5 μ)
Bakenuma:	410-670 μ	(514.9 μ)	30 45 μ	(37.95 μ)
Marunuma (a):	430-710 μ	(602.9 μ)	40 50 μ	(43.4 μ)
Marunuma (b):	400-610 μ	(497.8 μ)	6-10 μ	(7.75 μ)

Remarks. This species seems to be cosmopolitan, being distributed nearly all over the world except Central and South America. Thus many varieties or local forms have been hitherto described. But it is thought that not a few of these forms may be naturally attributed to a number of synonyms.

Observing the specimens obtained from this district, we may easily distinguish among them the two types, forma *typica* and forma *polyporis*.

The characteristics of the specimens belonging to forma *typica* (Text-fig. 1) are as follows. 1) The covering coat of the gemmule is rather thick being 30–65 μ thick. 2) The gemmule-spicules are great in number and are arranged radially. 3) Each gemmule has a single foramen which is protected by a cup-like or dish-shaped structure.

On the other hand, the characteristics of forma *polyporis* (Text-fig. 2) are as follows. 1) The covering coat of the gemmule is thin and is only 6-20 μ thick. 2) The gemmule-spicules are in most cases small in number but sometimes they are very few and are arranged tangentially. 3) Each gemmule has 1-7 or more foramens which have or have not a dish-like structure.

This plurality of the foramen is seen in the case of *Spongilla lacustris* var. *rhenana* (RETZER) which has 3 6 foramens and again in the case of *Spongilla lacustris* var. *multiforis* (CARTER) which has 1-5 foramens.

But these varieties are different from *Spongilla lacustris* forma *polyporis* in the following features of the gemmule-spicules. The gemmule-spicules of *S. lacustris* forma *polyporis* are slightly or strongly curved and are provided with a number of straight or curved spines; while the same of *S. lacustris* var. *rhenana* are symmetrically bent near each end, with a smooth surface.

The gemmule-spicules of *S. lacustris* forma *polyporis* are generally cylindrical and are either rounded or bluntly pointed at both ends; while

those of *S. lacustris* var. *multiforis* are fusiform and are sharply pointed at the extremities.

The specimens referable to the forma *typica* were collected from Uraike and Bakenuma; while those referable to the forma *polyporis* were obtained from Bakkonuma, Hyôtanike, Lake Shôsen, the River Icchian and Kajinuma.

The specimens of forma *typica* and of forma *polyporis* were obtained from Fujinuma and Marunuma at the same time and in the same place growing under the same conditions.

Judging from the above facts, it seems to me that these differences in characteristics shown by these two types are not caused by different ecological conditions but are the fixed and constant features proper to each type.

Thus it may be quite natural and reasonable to divide the specimens thus far obtained in this district into two groups, namely the one of *Spongilla lacustris* forma *typica* and the other of *Spongilla lacustris* forma *polyporis*.

2. Spongilla fragilis LEIDY
(Pl. VII, Figs. 14, 15; Text-fig. 5)

This sponge grows on the surface of submerged wood, trees, water plants, stones, rocks and other objects in either stagnant or running water at a depth of a few meters.

The external form of the sponge (Pl. VII, Figs. 14, 15) is generally in an encrusting layer but sometimes it is cylindrical or spindle-shaped growing around the stems of weeds, branches and other slender objects.

It is comparatively hard to the touch and brittle in consistence.

As a rule, the surface of the sponge is smooth, covered with a dermal membrane but sometimes it is rugged with many tubercles.

The oscula are relatively large and remarkable but in some specimens they are obscure. The pores are small and very abundant.

The colour of the sponge in life is green when grown in sufficient sun light, but it is yellow, grey or brown when grown in the shade.

Gemmules. The gemmules are formed abundantly throughout the whole sponge body. They are found in groups, each consisting of from 2 to 8 or more, and each group is covered with a common pneumatic coat. But on the other hand the gemmules are arranged on a pavement layer at the base of the sponge body and are invested with a common

pneumatic coat.   The pneumatic coat is composed of relatively large air-cells.

Each gemmule is relatively small, spherical or oval in shape, and is yellow, grey or brown in colour.   Usually it has a single foramen protected by a long straight or slightly curved tubule.
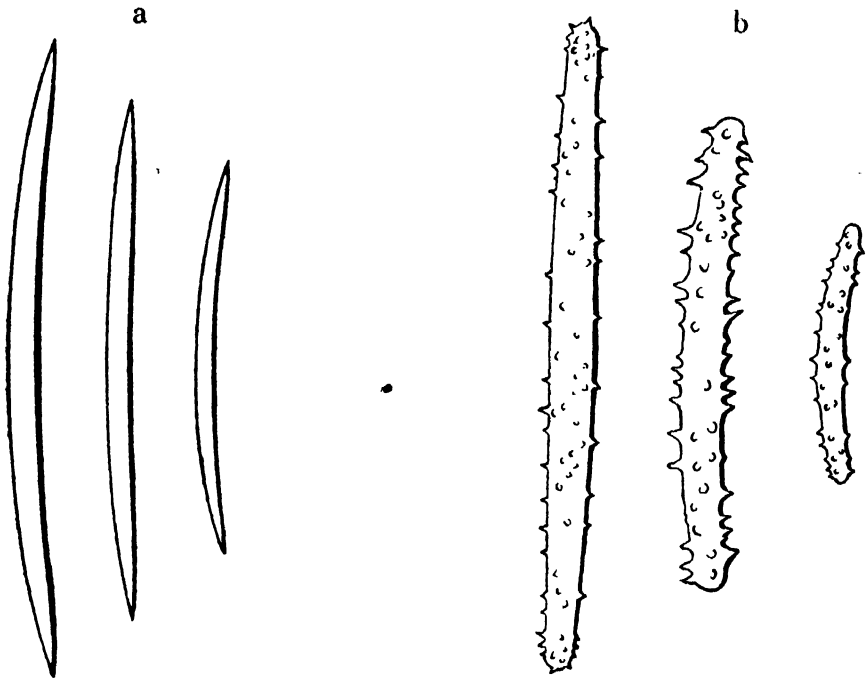
Text fig. 5. *Spongilla fragilis* LEIDY. a, Skeleton-spicules. b, Gemmule-spicules. (a ×240; b ×800). Specimen from Bakkonuma.

Spicules (Text-fig. 5).   The skeleton-spicules (Text-fig. 5, a) are smooth, straight or slightly curved, gradually or rather abruptly pointed at the extremities.

There are found no flesh-spicules.

The gemmule-spicules (Text-fig. 5, b) are cylindrical, straight or slightly curved, but somewhat swollen in the middle, bluntly pointed or rounded at both ends and are covered with a number of minute spines.

Localities.   Bakkonuma near Lake Raichishi, Province of Ushiro; Marunuma near Randomari, Province of Maoka.

Measurements.

Specimen from	Length	Diameter measured at the thickest portion
Marunuma:	(average)	(average)
Skeleton-spicules	220–330 μ (287.6 μ)	7–14 μ (10.96 μ)
Gemmule-spicules	52 115 μ (76.98 μ)	4– 7 μ (5.64 μ)
Bakkonuma:		
Skeleton-spicules	220–350 μ (292.3 μ)	8–14 μ (10.98 μ)
Gemmule-spicules	43–108 μ (78.5 μ)	4– 7 μ (5.81 μ)

Diameter of gemmules with a common pneumatic coat

	(average)
	450–850 μ (544.3 μ)
Diameter of a single gemmule	250–350 μ (290.8 μ)

Remarks. This sponge seems to be one of the most widely distributed fresh-water sponges. This time I was able to collect this species at only two places.

One was obtained from Bakkonuma and was about to disintegrate and the other was from Marunuma representing only a little bit of gemmules together with skeleton-spicules set on a tube made by some Trichoptera larva (Pl. VII, Fig. 15).

The gemmule-spicules taken from both the specimens in most cases were rounded at both ends, none of these being pointed.

3. Ephydatia mülleri (LIEBERKÜHN)
(Pl. VII, Figs. 16, 17, 18, 19; Text-fig. 6)

This sponge grows on the surface of submerged wood, trunks of trees, branches, stones and other objects in both stagnant and running water at a depth of 0.5–5 meters.

The external form of the sponge (Pl. VII, Figs. 16, 17, 18, 19) is that of an encrusting layer or of an irregular mass which is sometimes provided with a number of finger-like projections. The surface of the sponge is usually uneven and rugged. It is generally soft to the touch and is fragile in consistence.

The oscula are large in the well-developed specimens, but are small and obscure in the poorly developed ones. The pores are small and abundant.

The colour of the sponge in life is green when grown in sufficient sun-light, but is yellow, white, grey or brown when grown in the shade.

Gemmules. The gemmules are formed freely throughout the sponge body, but they are especially abundant in the basal portion. They are

variable in size, spherical. or ovoidal in form and yellow, white, grey or brown in colour.

Each gemmule is covered with a comparatively thick pneumatic coat in which one or two rows of gemmule-spicules are arranged radially. It has ordinarily one foramen but sometimes has two or more. The shape of the gemmule foramen is like a shallow dish.
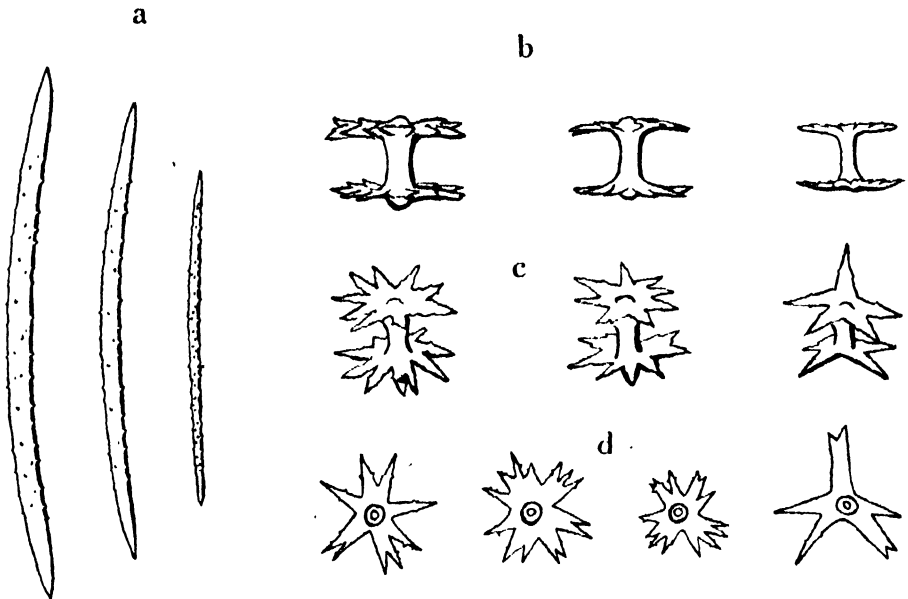
Text-fig. 6. *Ephydatia mülleri* (LIEBERKÜHN). a, Skeleton-spicules. b, Side view of gemmule-spicules. c, Oblique view of gemmule-spicules. d, Apical view of gemmule-spicules. (a ×240; b, c, d ×800). Specimen from Uraike.

Spicules (Text-fig. 6). The skeleton-spicules (Text-fig. 6, a) are straight or slightly curved, gradually and sharply pointed at the extremities and are usually covered with many minute spines.

There are no flesh-spicules.

The gemmule-spicules (Text-fig. 6, b, c, d) are of small birotulates. Generally the shaft of the birotulate is shorter than the diameter of the rotules and is covered with a number of very minute spines.

The margin of the rotule is deeply serrated.

Localities. Uraike No. 15 near Lake Taraika, Province of Shikuka; Fujinuma near Chinnai, Province of Kushunnai; Bakenuma near Lake Tôro, Province of Nayoshi; the River Icchian near Lake Tonnai, Province of Tonnai.

Measurement.

Specimen from	Length	Diameter	Rotule diameter
Fujinuma:	(average)	(average)	(average)
Skeleton-spicules	180–250 μ (215.0 μ)	6 – 9 μ (7.44 μ)	
Gemmule-spicules	12– 15 μ (13.1 μ)	2.5– 3.5 μ (3.00 μ)	16–22 μ (18.45 μ)
Bakenuma:			
Skeleton-spicules	190 300 μ (261.8 μ)	8 –12 μ (10.78 μ)	
Gemmule-spicules	13 · 18 μ (14.95 μ)	2 – 5 μ (3.30 μ)	16–24 μ (20.05 μ)
River Icchian:			
Skeleton-spicules	170–310 μ (249.6 μ)	5 –12 μ (9.9 μ)	
Gemmule-spicules	14 · 22 μ (16.95 μ)	2.5– 5 μ (3.4 μ)	18–25 μ (21.75 μ)
Uraike:			
Skeleton-spicules	190 300 μ (257.7 μ)	4 –12 μ (8.03 μ)	
Gemmule-spicules	11– 16 μ (13.35 μ)	2.5 3.5 μ (3.00 μ)	18 23 μ (20.3 μ)
Diameter of gemmules	(average)		
	400 670 μ (512.9 μ)		

Remarks. This sponge has also a world wide distribution as in the case of the preceding species. The specimens which I collected this time were growing on the surface of branches, stems or roots of water plants, and were likewise not very large, none being over 5 centi-meters in diameter.

Most of them were forming a thin layer and the gemmules were easily observed from the outside.

4.   Heteromeyenia baileyi var. petri (LAUTERBORN)

(Pl. VII, 20; Text-fig. 7)

This sponge grows on the surface of submerged wood, trunks of trees, branches, stems, roots of water plants and other objects found in both stagnant and running water 0.5–5 meters deep.

The sponge (Pl. VII, Fig. 20) forms a thin layer or a mass bearing sometimes a number of small projections.

It is soft and fragile in consistence.

The colour of the sponge in life is bright green when it is grown in sufficient sun-light and is yellow, grey or brown in the shade.

The oscula are large in the well-developed specimens but they are small and obscure in the case of the small ones. The pores are small in size but are great in number.

Gemmules. The gemmules are formed abundantly throughout the whole sponge body. They are spherical in form, yellow or brown in colour.

Each gemmule is covered with a well-developed pneumatic coat in

which the gemmule-spicules are arranged radially. The pneumatic coat consists of three layers, viz. a thick inner chitinous layer, a middle pneumatic layer and a thin outer chitinous layer. The middle pneumatic layer is composed of many small air-cells.

It has a single foramen protected by a long, straight or slightly curved tubule which is provided with cirrus appendages at its distal end.
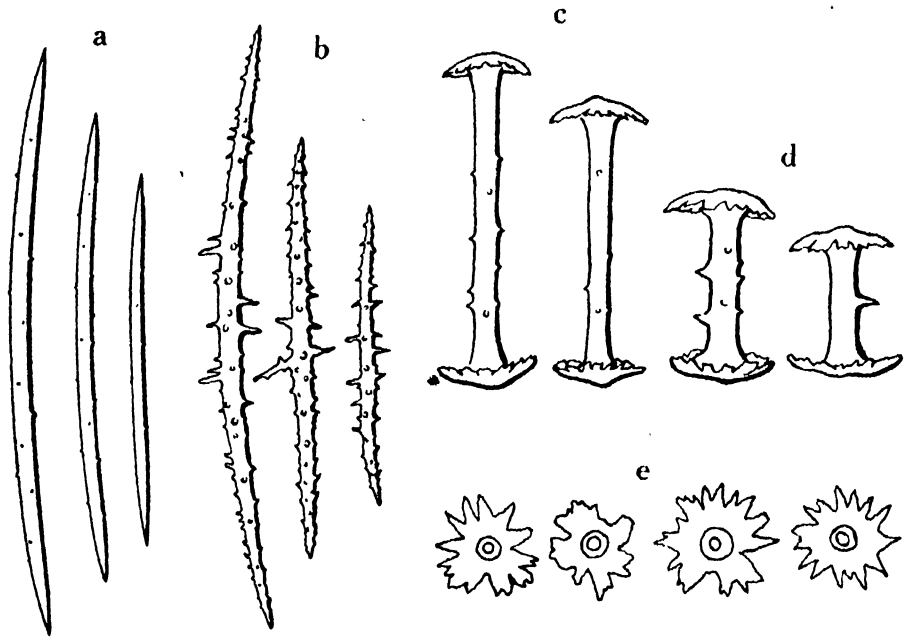
Text-fig. 7. *Heteromeyenia baileyi* var. *petri* (LAUTERBORN). a, Skeleton-spicules. b, Flesh-spicules. c, Longer gemmule-spicules. d, Shorter gemmule-spicules. e, Apical view of gemmule-spicules. (a ×240; b, c, d, e ×800). Specimen from Fujinuma.

Spicules (Text-fig. 7). The skeleton-spicules (Text-fig. 7, a) are slender, straight or slightly curved, gradually and sharply pointed at the extremities, and are either smooth or covered with a few minute spines.

The flesh-spicules (Text-fig. 7, b) are small straight or curved, gradually pointed at both ends and are provided with a number of spines of variable length.

The gemmule-spicules (Text-fig. 7, c, d) are birotulates of two kinds, the longer and the shorter. In both kinds of spicules, the shaft is longer than the diameter of rotules. The shaft is slender, straight or slightly curved and is either smooth or provided with a number of relatively large spines.

The rotules (Text-fig. 7, e) are either flat or curved towards the shaft and their margin is irregularly serrated.

Locality. Fujinuma near Chinnai, Province of Kushunnai.

Measurements.

Specimen from Fujinuma:	Length		Diameter		Rotule diameter	
		(average)		(average)		
Skeleton-spicules	210–320 μ	(266.1 μ)	5 9 μ	(6.76 μ)		
Flesh-spicules	49–103 μ	(70.51 μ)	3 · 3 μ	(2.49 μ)		(average)
Longer gemmule-spicules	42– 58 μ	(47.24 μ)	3 –4 μ	(3.24 μ)	15 -18 μ	(16.64 μ)
Shorter gemmule-spicules	25– 38 μ	(30.14 μ)	3.5–5 μ	(4.40 μ)	16 -21 μ	(18.42 μ)
		(average)				
Diameter of gemmules	430 700 μ	(586.9 μ)				

Thickness of the pneumatic coat

	Inner chitinous layer	5 - 7 μ
	Middle pneumatic layer	27–30 μ
	Outer chitinous layer	3– 5 μ

	Length	Diameter
Foraminal tubule of the gemmules	90 -123 μ	38 -45 μ

Remarks. This species was obtained only from Fujinuma. The specimens were found attached to the stems, the roots of water plants and to the tubes made by some Trichoptera larva. As a rule, they are small in size, being not longer than two centi-meters.

Generally the spicules taken from the specimens above mentioned are shorter than those taken from the specimens obtained from Hokkaidô and Honshû.

This tendency is most remarkable in the case of gemmule-spicules.

The average value of the gemmule-spicules of both specimens, obtained from Fujinuma and from Lake Abashiri in Hokkaidô, are compared in the following.

Specimen from	Longer gemmule-spicules		Shorter gemmmule-spicules	
	Length	Diameter of rotule	Length	Diameter of rotule
Fujinuma:	47.24 μ	16.6 μ	30.14 μ	18.4 μ
L. Abashiri:	72.4 μ	16.2 μ	49.6 μ	18.7 μ

The diameter of the rotules in each case shows nearly the same value, while the length of the gemmule-spicules from Fujinuma is much shorter than the same from L. Abashiri. ,That is to say, the average length of the longer gemmule-spicules in the specimen from Fujinuma is shorter than the length of the shorter gemmule-spicules in the specimen from L. Abashiri.

The thickness of the pneumatic coat of the gemmules from Fujinuma is 35–42 μ and it is thinner than that from L. Abashiri measured 49–68 μ.

It is interesting to see that both the length and the diameter of the foraminal tubules of the two are nearly the same as is shown in the next table.

Specimen from	Foraminal tubules of the gemmules	
	Length	Diameter
Fujinuma:	90–123 μ	38 45 μ
L. Abashiri:	100–125 μ	35 45 μ

Key to the fresh-water sponges of South Saghalin.

A. Gemmule-spicules rod-shaped, without transverse discs at the extremities, ...(Genus *Spongilla*).

   (1) Flesh-spicules present; pointed, spined acerates,. . .*S. lacustris*.

   (2) Flesh-spicules absent; gemmules covered with covering of polygonal air-cells, ...*S. fragilis*.

B. Gemmule-spicules with transverse discs at the extremities (viz. birotulates).

   (1) Birotulates of one kind; flesh-spicules absent, ...(Genus *Ephydatia*). Shaft of birotulates not longer than rotule diameter; skeleton-spicules micro-spined, ...*E. mülleri*.

   (2) Birotulates of two kinds, the one considerably longer than the other,.....................(Genus *Heteromeyenia*). Flesh-spicules present, spinous acerates, . .*H. baileyi* var. *petri*.

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EXPLANATION OF THE PLATES

PLATE V.

PLATE VI.

PLATE VII.

N. SASAKI: Fresh-water Sponges of South Saghalin.

SASAKI photo

N. SASAKI: Fresh-water Sponges of South Saghalin.

14

18

15

19

16

17

20

N. Sasaki: Fresh-water Sponges of South Saghalin.

A RE-EXAMINATION OF *PHERETIMA YAMADAI* HATAI, AN EARTHWORM FOUND IN JAPAN AND CHINA

By

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(Received April 8, 1939)

Pheretima yamadai HATAI

1930 *Pheretima yamadai*, HATAI, Sci. Rep. Tôhoku Imp. Univ., Biol., V, 4, pp. 664-666, fig. 8. (Tottori, Okayama, Wakayama, Kôbe and Hatta, Japan)

1931 *Pheretima pectinifera*, MICHAELSEN, Peking Nat. Hist. Bull., V, 3, pp. 15-17, figs. 7-9. (Soochow, China)

1933 *Pheretima yamadai* (part, B-form), CHEN, Contr. Biol. Lab. Sci. Soc. China, Zool. Ser., IX, 6, pp. 255-261, figs. 20 & 21. (Nanking, Chusan, Chuan-shan and Ning-po, China)

1935 *Pheretima pectinifera*, GATES, Smithon. Misc. Coll., XCIII, 3, pp. 13-14.

1936 *Pheretima yamadai*, CHEN, Contr. Biol. Lab. Sci. Soc. China, Zool. Ser., XI, 8, p. 272.

Material examined: Three cotype-specimens, with clitellar glandularity not yet complete, Tottori, Japan, May, 1930.

Description:

External characteristics:

Three specimens are incomplete being damaged in the posterior part of the body; moderate-sized worms; in the largest specimen, length 120+ mm, greatest diameter 6.8 mm, number of segment 103+. Colour in formalin: dorsally purplish brown with reddish tinge, ventrally lighter than the dorsal, clitellum deeply reddish purple. Prostomium, epilobous ca. 1/2-2/3. First dorsal pore in 12/13, distinct and functional; but, in all specimens, a rather distinct but non-functional pore-like marking was found in 11/12. Clitellum entire, in XIV-XVI, without setae; but intersegmental furrows are not yet completely obliterated.

Setae delicate and numerous, beginning on II; dorsal ones slightly more widely spaced than the ventral, but no marked difference is found in size between them. Middorsal breaks distinct, but midventral ones very slight if present. Approximate number of setae is follows: 54-63/III, 61-73/V, 69-74/VI, 68-75/VII, 71-81/VIII, 73-74/XII, 76-79/XX, 76-84/XXVI, spermathecal setae 29-33/VI, 32-34/VII, 31-37/VIII, 32-35/IX;

male pore setae 30–38 (of these, 7–11 on male disc).

The male pores are situated ventrolaterally on large discs of XVIII, about 3/7 of the circumference apart. In all cases, the copulatory chambers are everted showing the male discs. Each disc with lateral prepuce-like fold is prominently elevated from the general body surface, extending a little into both segments, anteriorly and posteriorly. On the disc, at the extreme lateral side which is slightly lower than the medial larger part, a minute tip bearing a male pore is found in the midst of four minute genital papillae which are placed very closely together; these porophore and genital papillae form, as a whole a small but definite cross-shaped body. A large raised part medial to the porophore is surrounded medially by a few circular furrows; on its surface, 7–11 setae are planted, and 3 (in all cases), small, circular, centrally depressed genital papillae are arranged, at equal distances from one another and on both sides pre-setal and postsetal.

Female pore single, midventrally placed on XIV.

Spermathecal pores, three pairs in 6/7–8/9, placed ventrolaterally, about 3/7 of the circumference apart; each is found within a wide slit (about 3–4 setal wide), always preceded by a fairly large spermathecal papilla which is situated on the posteriormost edge of the segment.

Genital papillae are frequently found on VII and VIII, presetal or postsetal or both, in position medial to the spermathecal pore-line with about 5 setal distance in the presetal case, and with about 8 in the postsetal case, almost similar in shape and in size to those (larger medial ones) on the male disc and slightly smaller than the spermathecal papillae.

The following table shows the occurrence and position of the genital papillae on both of the pre- and post-clitellar regions.

Specimen No.	Position	VII		VIII		XVIII	
		R	L	R	L	R	L
1	presetal	1	0	1	1	2	1
	postsetal	0	0	0	0	1	2
2	presetal	0	0	0	1	1	1
	postsetal	0	0	0	0	2	2
3	presetal	0	0	0	1	1	1
	postsetal	1	0	0	1	2	2

R right, L left

Internal anatomy :

Septa generally well-developed ; 5/6 and 6/7 much thickend and mus-
culated, 7/8 slightly and 10/11–12/13 moderately thickened, 8/9 and 9/10
absent.

Gizzard moderate in size and globular in shape, behind 7/8. Intestine
begins to swell in XV. Intestinal caeca in XXVII is complicated ; each
caecum consisting of 5 or 6 finger-shaped secondary caeca, of which the
dorsalmost is the longest and the largest, extending anteriorly to about
XXIII, the more ventrally placed ones become gradually smaller and shorter.

Hearts 4 pairs in X–XIII, small in calibre. Lymph glands small,
club-shaped, found behind 17/18 caudalwards.

Seminal vesicles two pairs, conspicuously large and voluminous, occupy-
ing nearly all of XI and XII, pushing both septa of 10/11 and 12/13
anteriorly and posteriorly, middorsally meeting with one another, rough
and granular on surface ; each with a dorsal lobe, similarly granular on
surface, very small in proportion to the large size of the main portion.
Testis sacs moderate in size, ventral in X and XI ; the anterior pair
form a thick U-shaped sac and the posterior pair form a somewhat
quadrate sac. Pseudovesicles are very small or vestigial in size, behind
12/13.

Prostate gland moderately large, in XVI– or XVII–XX, rectangular
in shape, transversely divided into lobes and again subdivided into lobules.
Duct moderate in length and thickness, usually curved in a U- or r-shape,
entally rather slender and ectalwards gradually increasing in thickness
and muscularity. Ectal end of the duct enters, through the glandular
tissue of the male disc, into a firmly-formed, glandular mass which corre-
sponds to the cross-shaped body, and indirectly opens at the tip of the
porophore on to the exterior (in these specimens ; opens within the
copulatory chamber when retracted). Embedded within the glandular
tissue are found some stalked accessory glands which correspond to the
genital papillae found on the male disc. Dorsally to the cross-shaped
body, some minute accessory glands with solid club-shaped stalk are
found around the ectalmost part of the prostatic duct.

Spermathecae fairly large, round sac-like but pressed into various
shapes. Duct thick, shorter than the diameter of the ampulla, slightly
narrowed at the ectal end, sharply marked off from the ampulla. Diverti-
culum a little longer than the main portion, curved or slightly twisted ;
ectal about 1/3 (as long as, or slightly longer than, the ampullar duct)
slender but slightly thick-walled, not distinctly marked off from the ental

slightly dilated and long seminal chamber. Close to the ectal end of each spermatheca and just in front of the septum is found a large stalked accessory gland which is associated with the spermathecal papilla. Accessory glands corresponding to the genital papillae are smaller than those of spermathecal ones.

Remarks :

MICHAELSEN ('31) reported a new species of earthworm in the name of *Ph. pectinifera* from China, but without any remarks to show its relation to the allied species. As CHEN noticed ('33 & '36), *Ph. pectinifera* seems apparently to be identical with HATAI's species, *Ph. yamadai* described in 1930. But, as the original description of the latter species was rather abbreviated, the re-examination of this species is desirable to prove their identity. Fortunately, through the kindness of Dr. S. HATAI, I was able to have the opportunity to examine three cotypes of *Ph. yamadai* obtained from Tottori.

There are two most salient characteristics in the present species, the one is of the male pore, and the other is of the complicated intestinal caeca. The general appearance of the male segment of this species resembles those of *Ph. asiatica*, *Ph. tibetana*, *Ph. tschiliensis*, *Ph. aggera*, *Ph. grahami*, *Ph. praepinguis*, *Ph. vulgaris* and *Ph. quelparta* ; in each of these species there are found in the ventrolateral position the copulatory chambers provided with crescent-shaped secondary male pores, and each of these chambers contains internally a male disc and a primary male porophore. On the male disc, some setae are always planted and some genital papillae are usually found. GATES ('35) says of the synonymy of " *Ph. pectinifera* " at least four of the Hamburg specimens labelled ' *Ph. pingi* ' are obviously *Ph. pectinifera* (*Ph. pingi* = *Ph. carnosa*). It is difficult to understand how MICHAELSEN should have confused these two species because some quite different features exist in their male pores.

In *Ph. yamadai*, a minute porophore is found on the extreme lateral side of the male disc, and in the midst of four minute genital papillae which are close to each other and which form, as a whole, a very small but definite cross-shaped body. Such a structure is not found, at least, in the cases of *Ph. tschiliensis*, *Ph. aggera* and *Ph. quelparta*, but is identical with the structure in A- and B-form of CHEN's *Ph. yamadai*. Thus the opinion given by GATES that CHEN's A-form is identical with *Ph. tschiliensis* seems to be not correct. But I also think that CHEN's species include two species represented by A- and B-forms ; B-form is *Ph. yamadai* and A-form is a form (perhaps specifically) distinct from

both of *Ph. yamadai* and *Ph. tschiliensis*.

The position, numerically speaking, of the segment in which the lymph glands first appear may be taken as one of the diagnostic characteristics. In *Ph. yamadai* they are found behind 17/18. In the species described by CHEN it is said there is "no trace of lymph gland". Possibly, this description might be based upon the examination of his A-form. In the case of *Ph. pectinifera*, no description of this organ was made by MICHAELSEN.

The presence of complicated caeca, and the absence of male pores are the distinct characteristics, which have been found in many species of the Japanese *Pheretimas*. In *Ph. yamadai*, each caecum consists of 5 or 6 finger-shaped secondary caeca as shown in MICHAELSEN's figure of *Ph. pectinifera* and as seen in many of the Japanese species such as *Ph. hilgendorfi, Ph. agrestis, Ph. vittata*, etc. In the Chinese *Pheretima* species, *Ph. schmardae* and the present species have the complicated caeca, and both of these two species are also found in Japan. It is possible that they may have been imported into China from Japan by some human agency. By this characteristic of the caeca alone *Ph. yamadai* is easily distinguished from the foregoing closely related species.

As already indicated in the above description, the Japanese form similarly to the Chinese, has the genital papillae in the spermathecal region, though the occurrence of these organs has not been given in HATAI's description.

REPORT OF THE BIOLOGICAL SURVEY OF MUTSU BAY
34. THE POLYCLADA OF MUTSU BAY[1]

BY

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(With Plates VIII IX and 10 text-figures)

(Received April 8, 1939)

The material of the polyclad turbellarians dealt with in the present study is chiefly the collection made by the biological survey of Mutsu Bay which was carried out by the Tôhoku Imperial University, and is partly my own collection made during a short stay at Asamusi in June, 1938. Of the 13 species listed below, 5 are apparently new to science.

ACOTYLEA

Family Stylochidae

1. *Stylochus aomori* KATO

Family Cryptocelidae

2. *Cryptocelis orientalis* sp. nov.

Family Leptoplanidae

3. *Notoplana humilis* (STIMPSON)
4. *Stylochoplana pusilla* BOCK
5. *Hoploplana deanna* sp. nov.

Family Planoceridae

6. *Planocera reticulata* (STIMPSON)

Family Diplosolenidae

7. *Pseudostylochus intermedius* sp. nov.
8. *Pseudostylochus aino* KATO
9. *Pseudostylochus takeshitai* YERI et KABURAKI

COTYLEA

Family Pseudoceridae

10. *Pseudoceros asamusiensis* sp. nov.

Family Eureleptidae

11. *Cycloporus papillosus* (M. SARS)

12. *Stylostomum hozawai* sp. nov.

Family Prosthiostomidae

13. *Prosthiostomum auratum* KATO

Before proceeding further I should like to express sincere acknowledgements to Dr. S. HÔZAWA, Professor of the Tôhoku Imperial University, for his kindness in placing the valuable material at my disposal for study. My deepest thanks are also due to Dr. S. KOKUBO and Mr. N. ABE for their kindness shown me during my stay at Asamusi.

1. Stylochus aomori KATO

Stylochus aomori : KATO, 1937 c, pp. 39-41.

This planarian is commonly found creeping on the muddy beach at Asadokoro near Asamusi at low tide, and is rarely found in the burrow of *Callianassa* sp. I happened to observe the animal moving at about the rate of 30 cm per minute on the beach in the day time in June.

The body is oval in shape, usually attaining 30 mm in length and 20 mm in breadth. The ground colour of the dorsal surface is light brown, over which are uniformly scattered numerous dark green patches and spots. A pair of slender nuchal tentacles are situated at about one-sixth the length of the body from the front.

2. Cryptocelis orientalis sp. nov.

(Pl. VIII, Figs. 1, 2; Text-figs. 1, 2)[1]

A single specimen of this new species was collected at Moura-sima by Prof. S. HÔZAWA on July 11, 1926.

In the preserved state the body is thick, of a leaf-like shape with broadly rounded anterior and posterior ends. It measures 30 mm long by 20 mm broad, and the colour is uniformly brown.

At the rear limit of the first sixth of the body-length a small brain is located on the middle line. A large number of minute ocelli are distributed in the frontal part of the body, more densely scattered around the brain. Tentacles are totally lacking. The tentacular groups of eyes are scarcely distinguishable from the cerebral ocelli in the available specimen.

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[1] For abbreviations in this and subsequent figures see p. 153.

Marginal eyes are arranged in rows along the whole dorsal margin, being distributed more densely at the anterior end. The mouth is situated at about the centre of the body, and the plicated pharynx occupies the middle third of the body-length.

Immediately behind the posterior end of the pharyngeal sheath there is a small male genital pore, which passes through the short antrum into the characteristic large prostate vesicle with a thick mus-cular envelope. The latter vesicle is, as usual, composed of two parts; the distal part, which is continuous with the antrum, and which is a long duct with numerous deep folds, provided with the outer thick layer of sub-epithelial gland cells; the proximal part is an irregu-larly ovoid body, into which is discharged a large quantity of eosinophilous secretion granules from the extra-capsular glands. A pair of seminal canals pierce the
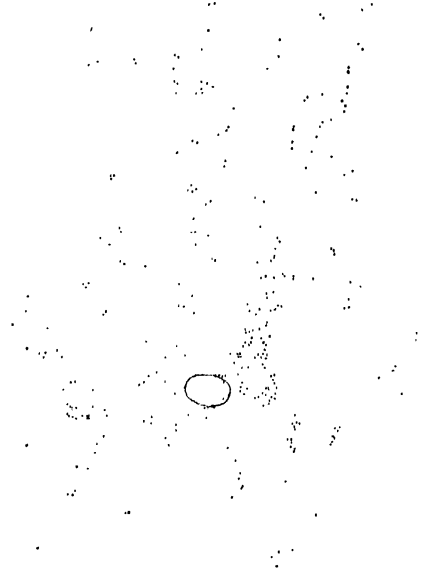
Text-fig. 1. *Cryptocelis orientalis*; arrangement of eye-spots. ×20.
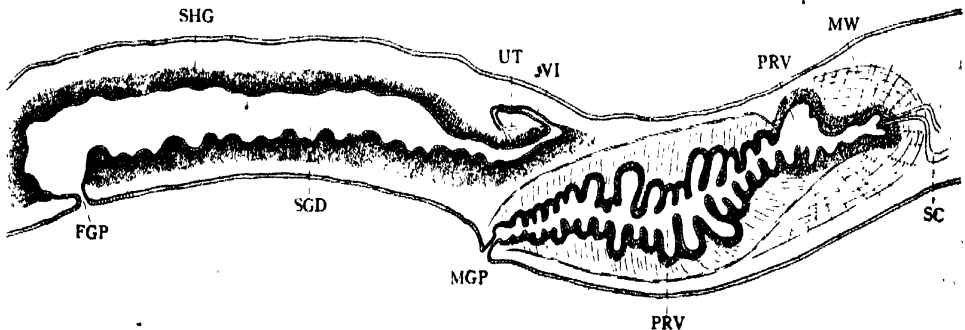
Text-fig. 2. *Cryptocelis orientalis*; sagittal section through genital organs. ×17.

thick muscular wall to open into that proximal part of the prostate at about the middle point.

The female gonopore is at some distance from the male one, being situated a little behind the level of the last sixth of the body-length. The general plan of the female organs is quite in accord with that of other species of the genus.

The genus *Cryptocelis* contains three European species (*alba*, *compacta*, *glandulata*) and three Japanese ones (*ijimai*, *amakusaensis*, *littoralis*) ; of these species the planarian under consideration resembles *littoralis* (KATO, 1937 f), more closely than any others in the general structure of the reproductive organs, but differs from it distinctly in the arrangement of eye-spots as well as in the shape of the prostate vesicle.

3. Notoplana humilis (STIMPSON)

Leptoplana humilis : STIMPSON, 1857, p. 9.
Notoplana humilis : YERI et KABURAKI, 1918, pp. 11–13.

This is the polyclad most commonly found on the coasts of Japan.

The body is of an elongated shape with a broadly rounded anterior extremity and a bluntly pointed posterior end. It measures usually less than 20 mm in length, but the larger individuals attain 30 mm in length. There are a pair of small nuchal tentacles. The colour of the body is generally grey or light brown.

Localities : Gomi-sima, Moura-sima, Tappi-sima, Urata, neighbourhood of the Station.

4. Stylochoplana pusilla BOCK

Stylochoplana pusilla : BOCK, 1924, pp. 1 24; KATO, 1934. pp. 124 125.

This species is a small parasitic form, found in the mantle cavity of *Monodonta labio*. In the vicinity of the Station it also harbours in the mantle cavity of *Cellana toreuma*.

Distribution in Japan : Susaki near Simoda, Misaki, Asamusi.

5. Hoploplana deanna sp. nov.

(Pl. VIII, Figs. 3, 4; Text figs. 3, 4)

A single specimen of this species was obtained by Dr. S. TAKATUKI at a depth of 10 m off Aburakawa on Sept. 11, 1926.

The body is rather thick, elongated oval in shape, and the anterior

end is more broadly rounded than the posterior. It measures 14 mm long by 6 mm broad. The colour of the body in the preserved state is a uniformly brown. A pair of long, slender tentacles lie a little anterior to the level of the first quarter of the body. There are a large number of ocelli in the interior of the tentacles.' Slightly in front of the level of the tentacles is situated a small brain, on either side of which are arranged a certain number of cerebral eye-spots. The mouth is placed subcentrally, and the plicated pharynx is very large,

Proceeding forward from the hind part of the body, the seminal canals turn backwards at the level of the mouth, and each dilates into
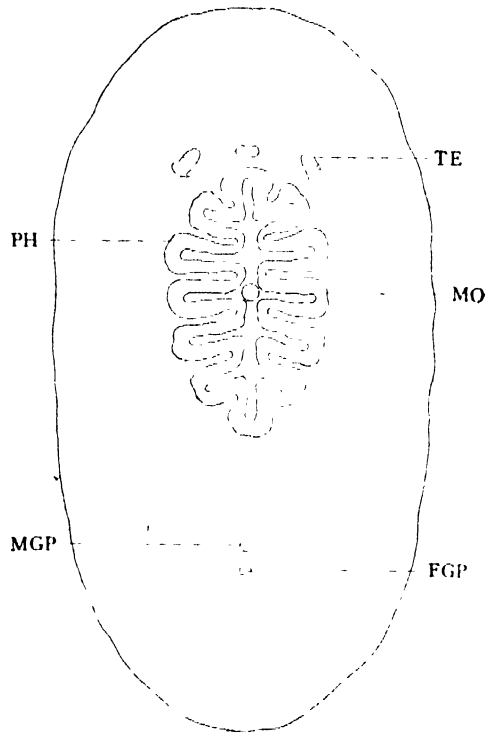
Text-fig. 3. *Hoploplana deanna.* ×7.
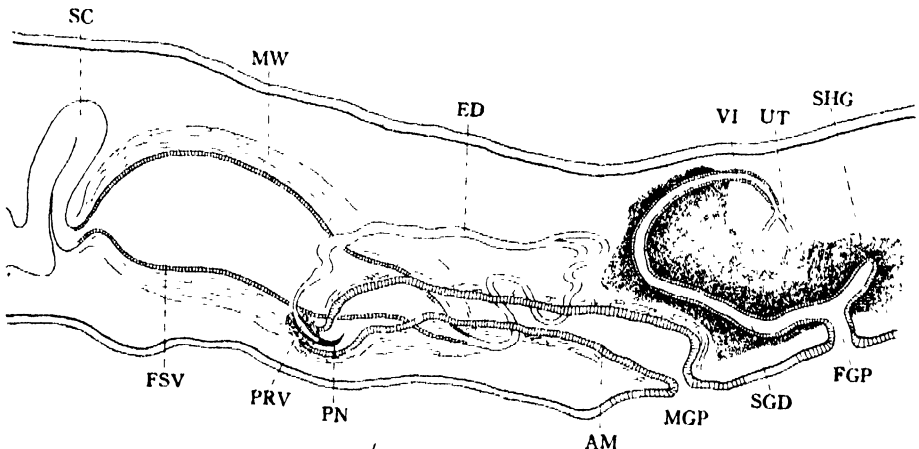
Text-fig. 4. *Hoploplana deanna;* sagittal section through genital organs. ×55.

a large false seminal vesicle directly behind the posterior end of the pharyngeal chamber. The latter vesicle is of a spindle-shape, provided with a well-developed muscular wall. From its distal end arises a narrow duct, which follows a tortuous course inwards and backwards uniting with the duct of the other side to form an ejaculatory duct. This runs forward for a long distance, and curves postero-ventrally to merge into a small pyriform prostate vesicle, lying at the base of the penis. The penis is represented by a slender, curved stylet with a sharply pointed end, and opens into the antrum masculinum. The antrum is wide and deep, and vertically disposed. A little apart from the male genital pore, there is a female aperture, which continues through the short antrum to the shell gland duct. This duct runs dorsally in a looping course to lead into the vagina interna, which receives a pair of uteri. The genital pores lie between the last fifth and sixth divisions of the body-length.

There have been recorded 7 species of *Hoploplana*, *i. e.*, *grubei*, *inquilina*, *insignis*, *papillosa*, *ornata*, *villosa* and *cupida*; of these the last three are the Japanese species. The present worm is easily distinguished from these species externally in the rather elongated shape of the body, and internally in the shape of the penis, and in the vertical disposition of the antrum masculinum.

6. Planocera reticulata (STIMPSON)

Stylochus reticulatus: STIMPSON, 1855, p. 381.
Stylochoplana reticulata: STIMPSON, 1857, p. 11.
Planocera reticulata: LANG, 1884, p. 445.
Planocera reticulata (STIMPSON): YERI et KABURAKI, 1918, pp. 19-22.

This is, as *Notoplana humilis*, one of the most common polyclads found on the coasts of Japan. A large number of them are found at Yuno-sima. Multi-tentacular forms also occur.

7. Pseudostylochus intermedius sp. nov.
(Pl. VIII, Figs. 5, 6; Text-fig. 5)

Several examples of this new species were obtained by myself at the eastern beach of Yuno-sima and in the neighbourhood of the Station.

The body is oval in form, measuring 40 mm long by 20 mm broad in the larger individuals. The colour of the dorsal surface is light brown, becoming darker in the central parts, and is uniformly spotted all over with small brown and darkish green spots.

A pair of nuchal tentacles lie at a distance of about one-fifth the body-length from the anterior end. The tentacular and cerebral eyes are arranged in the manner shown in Plate VIII, Fig. 5. The position of the mouth is nearly in the middle of the body and leads into the pharyngeal chamber, which encloses the elongated and plicated pharynx.
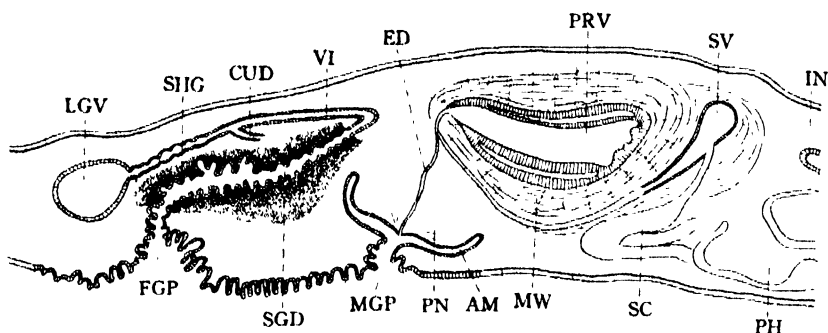
Text-fig. 5. *Psudostylochus intermedius;* sagittal section through genital organs ×23.

Structurally with regard to the genital organs, the present specimen agrees well with other species of the genus.

The genus *Pseudostylochus* contains 13 species, which are divided into two groups by the existence or absence of the sucking structure around the female genital pore. The group A (no sucking structure) includes *obscurus, takeshitai, fulvus, fuscoviridis, elongatus* and *longipenis;* the group B (with sucking structure) includes *okudai, stimpsoni, aino, edurus, maculatus, meridialis* and *nationalis*. Among the species contained in group B, *stimpsoni, edurus* and *maculatus* have the male genital pore lying at the centre of the antrum, while in the remaining species it opens outside near the posterior portion of the antrum. This flatworm, therefore, belongs to the *stimpsoni*-group, and is clearly distinguished from the allied species by the shape and position of the prostate vesicle.

8. Pseudostylochus aino KATO

Pseudostylochus aino: KATO, 1937 e, pp. 129–130; 1939, pp. 75–76.

A single specimen was collected by myself at Yuno-sima.

In the external appearance this species closely resembles *Pseudostylochus intermedius* mihi, but differs markedly from it in the minute structure of the reproductive organs. The body in life is of an oval shape, the

posterior end being a little narrower than the anterior.

Distribution in Japan: Muroran, Onagawa, Asamusi.

9. Pseudostylochus takeshitai YERI et KABURAKI

Pseudostylochus takeshitai : YERI et KABURAKI, 1918, pp. 26-28; KATO, 1939, pp. 74-75.

A single example of this species was obtained by myself at Gomi-sima.

The body is broadly elongated, the anterior end being more rounded than the posterior. It measures 25 mm long by 10 mm broad. The colour of the dorsal surface is buff with minute brown spots, and darker along the median line. The nuchal tentacles are very small and bluntly conical, situated at about the hind border of the first quarter of the body. The structure of the genital organs has been described in detail in my last paper.

Distribution in Japan: Misaki, Onagawa, Asamusi.

10. Pseudoceros asamusiensis sp. nov.

(Pl. IX, Figs. 4 6; Text-figs. 6, 7)

The collection contains a large specimen of *Pseudoceros*, which represents a new species. It was obtained by Dr. S. TAKATUKI by dredging among the sea-weeds between Yuno-sima and Benten-sima on May 26, 1926.

The body is leaf-like, elongated oval in shape with very frilled margin, and the anterior end forms a pair of prominent marginal tentacles, over which are scattered numerous ocelli. On the median line and near the base of the tentacles, there is a cluster of cerebral eyes with a couple of ventral ocelli. The body, in the preserved state, measures about 10 mm in length. The colour has totally faded.

The mouth is placed just behind the brain, and leads into the lobed pharyngeal chamber. The intestinal branches finely anastomose. The sucker lies at the posterior end of the

Text-fig. 6. *Pseudoceros asamusiensis.* ×2/3. ,

first third of the body-length. Between the rear end of the pharyngeal chamber and the sucker, there are a male and a female genital pore. The principal structure of the reproductive organs is similar to that of other *Pseudoceros.*.
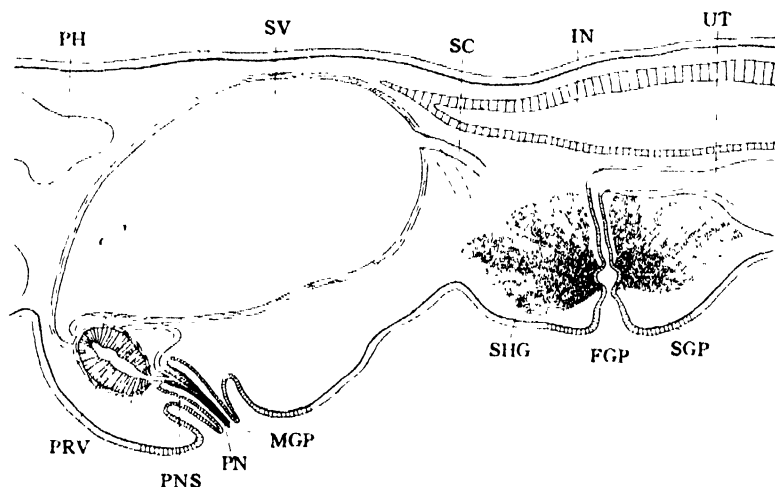
Text-fig. 7 *Pseudoceros asamusiensis;* sagittal section through genital organs. ×17.

The genus *Pseudoceros* contains a large number of species recorded from various localities all over the world, and of these 14 are Japanese species. This planarian differs from the other members of the genus in the arrangement of eye-spots, as well as in the shape of the marginal tentacles.

11. Cycloporus papillosus (M. SARS)

(Text-fig. 8)

Cycloporus papillosus: LANG, 1884, pp. 568–571.
Cycloporus papillosus (M. SARS): BOCK, 1913, pp. 262–264; YERI et KABURAKI, 1918, pp. 40–41; KATO, 1937 a, pp. 229–230.

Five specimens referable to *Cycloporus papillosus* var. *misakiensis* were found by myself on compound ascidians at Gomi-sima.

The body is oval in shape, provided with a pair of rudimentary marginal tentacles at the anterior end of the body. The larger specimens measure 20 mm in length. The colour of the body is fairly variable, but usually ochraceous, flecked with numerous russet spots. The tentacular

eyes are distributed at the base of each marginal tentacle, and cerebral eyes are arranged in two distinct groups over the brain region. The number of ocelli is more abundant in the present specimens than in those from the southern regions. The mouth lies immediately behind the brain,
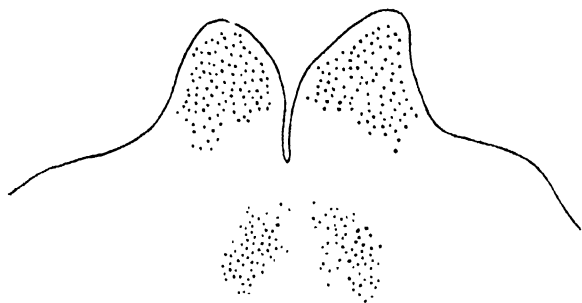
Text-fig. 8. *Cycloporus papillosus;* arrangement of eye-spots. ×14.

and the sucker is nearly at the centre of the body. The male and female gonopores are situated between the mouth and the sucker. In this genus the terminal parts of the intestinal branches open to the exterior by minute pores on the lateral body margin, and this structure is easily recognized under a lens in the living state of the animal.

12. Stylostomum hozawai sp. nov.
(Pl. IX, Figs. 1–3; Text-figs. 9, 10)

This new species is based on two specimens collected by myself at Gomi-sima on a certain orange-coloured compound ascidian between tide-marks on June 15, 1938.

The body in life is elongated oval in form with broadly rounded ends, measuring 6 mm long by 3 mm broad. The translucent body appears to be orange in colour owing to the contents of the finely branched intestine. Judging from the similarity of colouration, this worm seems to obtain nourishment from the said ascidian.

This worm has no recognizable marginal tentacles, while all other known members of the genus are provided with them. However, at the normal position of the tentacles are present a few eye-spots on either side of the midline. A small brain lies at the posterior end of the first seventh division of the body, and on each side of the brain are arranged the cerebral eye-spots with a pair of ventral ocelli. The dorsal epidermis is three times as high as the ventral one. They are composed of ciliated

columnar cells, which contain a large amount of rhabdites and other eosinophilous secretions.

A little behind the brain lies a pharyngeal chamber having a simple pharynx represented by a cylindrical tube. The mouth and the male genital pore communicate with a common atrium, which opens outside close behind the anterior end of the pharyngeal chamber. The intestinal branches are finely bifurcated, but do not anastomose. The sucker is situated nearly in the middle of the body.

A pair of the seminal canals proceed forward from the hinder part of the body, and a little in front of the level of the female gonopore they turn medially to unite into a single duct. This immediately opens into a large elongated seminal vesicle containing a mass of spermatozoa. Springing from the anterior end of the seminal vesicle, the ejaculatory duct soon unites with the duct of the prostate vesicle at the base of the penis, and makes its way at the pointed penial stylet into a deep and long penis sheath. The antrum masculinum, as mentioned above, opens
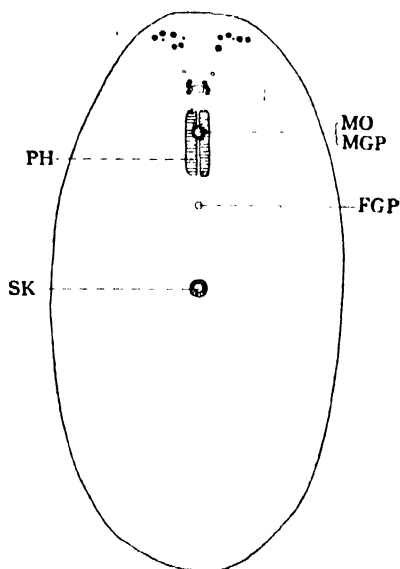
Text-fig. 9. *Stylostomum hozawai.* ×22.
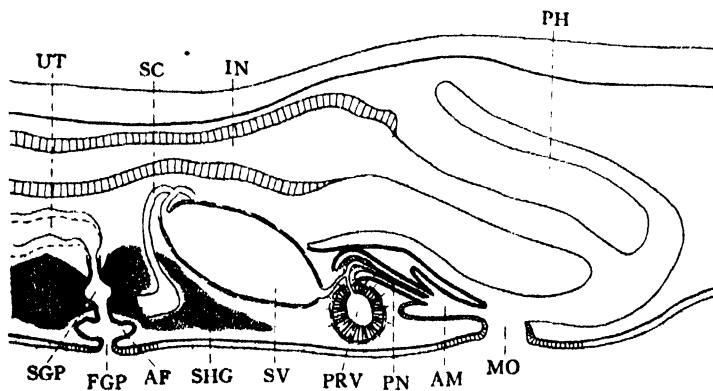
Text-fig. 10. *Stylostomum hozawai*; sagittal section through genital organs. ×90.

outside with the mouth.   The prostate vesicle is almost elliptical in shape, provided with numerous extracapsular glands and a thin muscular wall. It lies ventrally to the seminal vesicle, while in all other species of the genus it is dorsally disposed.

Close behind the mouth, there is a female gonopore which leads upwards into a large antrum femininum ; this passes into the shell gland pouch supplied with a large quantity of a shell secretion.   The uteri are expanded with ova.

The genus *Stylostomum* has hitherto included three valid species viz.: *S. ellipse* (DALYELL) (BOCK, 1913) from Europe, *S. lentum* HEATH et McGREGOR (1912) from the Pacific coast of North America and *S. frigidum* BOCK (1931) from the Indian Ocean.   But the species under consideration is clearly distinguished from these three forms by the absence of marginal tentacles, as well as by the smaller number of the tentacular and cerebral ocelli.   The position of the prostate vesicle is also a characteristic feature.

I take great pleasure in naming this species in honour of Professor S. HÔZAWA.

13.   Prosthiostomum auratum KATO

Prosthiostomum auratum :   KATO, 1937 f, pp. 363-364; 1938 b, p. 589.

Several specimens were collected by myself at Yuno-sima, and a single example at Urata by Dr. S. TAKATUKI on July 13, 1926.

This is a slender, delicate form, measuring 25 mm long by 4 mm broad in the larger individuals.   The colour is uniformly yellow. . The sucker is nearly in the central part of the body.

Distribution in Japan :   Asamusi, Misaki, Susaki, Seto, Tomioka, Nanao.

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EXPLANATION OF PLATES

ABBREVIATIONS

AF antrum femininum; AM antrum masculinum; CUD common uterine duct; ED ejaculatory duct; EP epidermis; FGP female genital pore; FSV false seminal vesicle; IN intestine; LGV LANG's glandular vesicle; MGP male genital pore; MO mouth; MW muscular wall; PH pharynx; PN penis; PNS penis sheath; PRV prostate vesicle; SC seminal canal; SGD shell-gland duct; SGP shell-gland pouch; SHG shell-gland; SK sucker; SP sperm; SV seminal vesicle; TE tentacle; UT uterus; VI vagina interna; ♂ male genital pore; ♀ female genital pore.

PLATE VIII

1. *Cryptocelis orientalis* sp. nov. ×1.
2. Ditto, sagittal section through genital organs. ×15.
3 and 4. *Hoploplana deanna* sp. nov., sagittal section through genital organs. ×40.
5. *Pseudostylochus intermedius* sp. nov., arrangement of eye-spots. ×15.
6. Ditto, sagittal section through genital organs. ×12.

PLATE IX

1. *Stylostomum hozawai* sp. nov. ×13.
2. Ditto, sagittal section of the body along the median line. ×30.
3. Ditto, sagittal section through genital organs. ×130.
4. *Pseudoceros asamusiensis* sp. nov., sagittal section through genital organs. ×15.
5. Ditto, cerebral group of eye-spots. ×26.
6. Ditto, marginal tentacles with eye-spots. ×12.
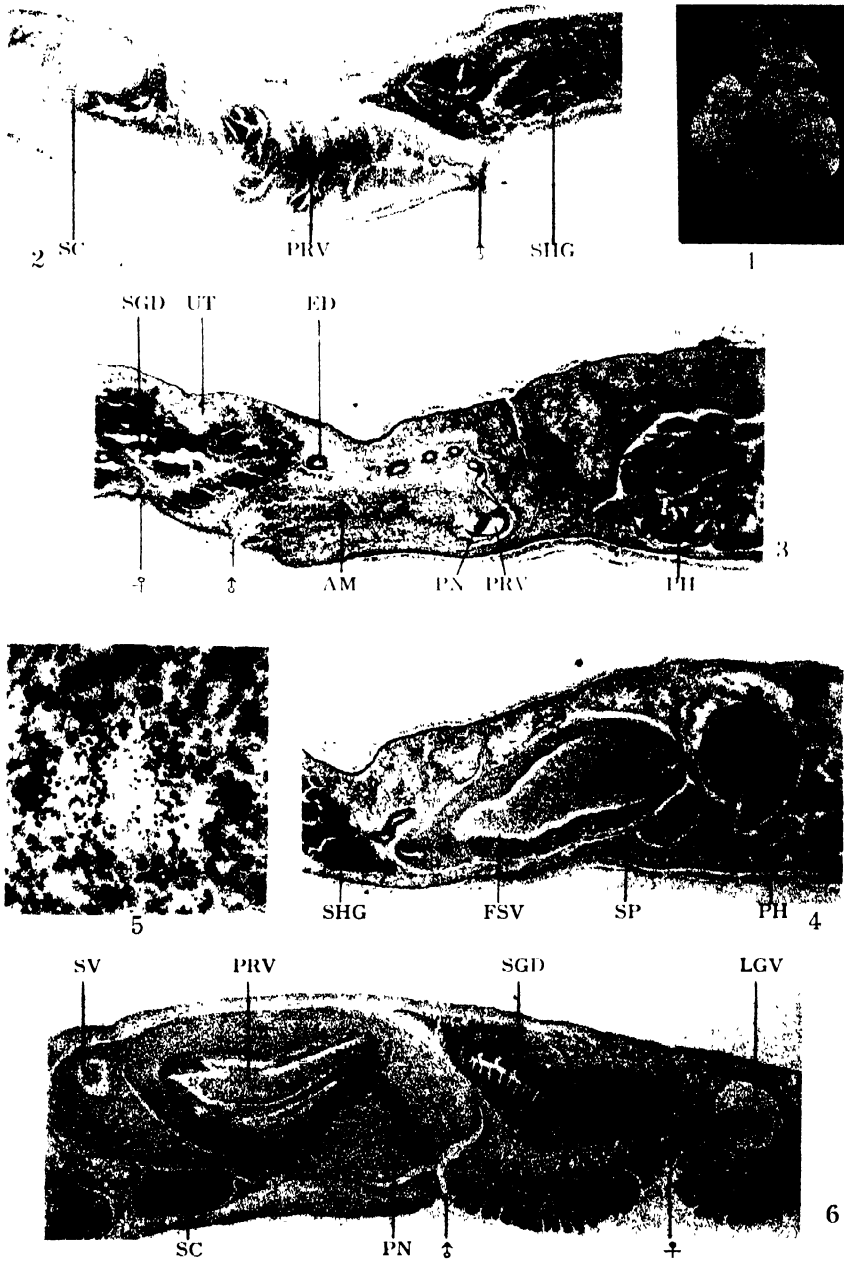
K. Kato photo.

Polyclada of Mutsu Bay.

Polyclada of Mutsu Bay,

A STUDY OF THE CAUDATE HOLOTHURIAN, *MOLPADIA RORETZII* (V. MARENZELLER)[1]

By

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(With Plates X XII and 23 text-figures)

(Received April 14, 1939)

CONTENTS

I. INTRODUCTION

We have not hitherto had much acquainted with the members of the family *Molpadiidae* on account of the great difficulty in securing material to enable us to make a thorough investigation. This seems to be specially true in the case of the Genus *Molpadia* of the same family, and there are many interesting problems in connection with this genus remaining to be solved.

The Holothurians belonging to the Genus Molpadia have been often dealt with from the systematic view point by many investigators such as

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[1] Contribution to the Onagawa Oceano-chemical Laboratory of the Tôhoku Imperial University.

LUDWIG (1891), CLARK ('07), and HEDING ('31). The differences in opinion expressed by these workers chiefly arise, according to DEICHMAN ('36), from a lack of knowledge based upon the actual observation of this animal.

I have undertaken, at the suggestion of Prof. Dr. S. HÔZAWA, the study of *Molpadia roretzii*. Fortunately I was able to carry out the study fairly thoroughly having obtained specimens in great abundance from the waters near the Onagawa Oceano-chemical Laboratory of the Tôhoku Imperial University.

I gladly take this opportunity to express my hearty thanks to Prof. S. HÔZAWA for the invaluable help he gave me during the prosecution of this study. I would likewise make grateful acknowledgment to Dr. T. IMAI, the head of the Onagawa Oceano-chemical Laboratory, for his kind guidance and suggestions made during the course of my study. I am also indebted to Mr. M. KATÔ, one of the members of our Biological Institute, who most kindly gave me valuable advice.

II. MATERIAL AND METHODS

The animal dealt with in the present paper was for the first time described by EMILE V. MARENZELLER in 1881 under the name of *Ankyroderma roretzii*. In 1907 H. L. CLARK placed this animal in the Genus *Molpadia* as distinguished from the Genus *Ankyroderma*. But in 1931, S. G. HEDING in attempting classification of the family *Molpadiidae*, placed the species belonging to the genus *Ankyroderma*.

The specimens which were used in the present study were about 300, in number collected at various times during 1937 by means of dredging. From five to ten specimens were obtained at every trial of the dredge which operated at the sea-bottom at a depth of about 30 meters in the vicinity of the Onagawa Laboratory.

In order to narcotize the animal in an expanded condition, some menthol crystals were added to the sea-water. In order to kill and to fix the material, PERENYI's fluid was chiefly used. Such fixatives as BOUIN's fluid, SCHAUDIN's fluid, 95% alcohol and NAWASCHIN's fluid were also tried and good results were obtained. Both paraffin and celloidin sections were prepared for microscopic observation. In staining the sections HEIDENHAIN's iron-alum haematoxylin combined with orange G, DELAFIELD's haematoxylin combined with eosin and MALLORY's triple staining were used. Sodium hydroxide solution was used in the preparation of the calcareous ring and of the spicules.

III BIOLOGICAL NOTES

1. The habitat

The habitats of the *Molpadia roretzii* are not known anywhere in the world except in Japan. Many habitats are recorded in Japan, such as the Uraga Channel, the Sagami Sea, Suruga Bay, the Echizen Sea, Mutsu Bay, Kagoshima Bay, and Asamusi. In these habitats the specimens, as in the cases of the other *Molpadia*, are obtained usually from depths of more than 100 meters. But in the vicinity of Onagawa, they may be taken from the muddy bottom at a depth of from 15 to 30 meters only.

Judging from the experience obtained from the culture of this animal in an acquarium, in its natural condition it seems to bury itself in the muddy sea-bottom in a posture with the head directed downwards, the anus pointing upwards and the body axis making an inclination of about 50 with the surface of the sea-bottom (text-fig. 1).

Text-fig. 1. *M. roretzii* (7 cm long) laid in the acquarium of sea-water with mud The tips of the tail of other animals exposed out side of mud.

2. The movement

If the *Molpadia* is placed on the muddy bottom of the acquarium, it begins to burrow slowly into the mud. The first movement which appears in the anterior region of body is represented by an extension of the dorsal wall, and by a contraction of the ventral wall. The inclination of the head is more or less influenced by the shape of the calcareous ring situated inside the head region. Thus, if the head is inclined downwards,

the tentacular crown will reach the surface of the bottom mud, then half
the tentacles are stretched forward intruding into the mud. Pushing
aside some amount of mud by means of their three digits, these tentacles
bend slowly outward, then the remaining half of the tentacles, which
hitherto were bending outward, begin to turn inward. By these move-
ments of the tentacles together with the contractions of the body-muscu-
lature the animal burrows completely into the mud in the course of from
10 to 20 minutes. When the *Molpadia* is placed in a vessel containing
sea-water but without mud at the bottom it usually rests quietly on one
side of the body. The body curls dorsally, and the tentacles are withdrawn
inside entirely. The forward movement of this animal is achieved in such
a way that a contraction occurs first at the caudal region and is transferred
anteriorly, and thus this animal proceeds forward a little distance at a
time. The rate of locomotion so far as I could ascertain was about 1 cm.
per minute.

Mud is swallowed by the mouth at every forward movement of this
animal. If we examine the contents of the alimentary canal, we find
various organic detritus forming the principal food.

IV MORPHOLOGY

1. The external features

The body is of a more or less elongated spindle-shape, provided
anteriorly with a circular oral disc, and posteriorly it becomes narrow
forming a caudal portion. It has neither tube-feet nor papilla on the
body-surface and thus it is difficult to determine the dorsal and ventral
sides without seeing the genital papilla which is dorsal in position. The
ratio of the body-breadth to the body-length is usually 1 : 4 but it becomes
nearly 1 : 1 in some contracted specimens, and is 1 : 8 in some extended
ones. The caudal portion is usually not more than one seventh of the
whole of body-length and is usually curved, its axis making some angle
with that of the body. The great majority of the specimens procured
are 8 cm in total body-length, while the largest one is as much as 18 cm,
and the smallest only 1.5 cm. The colour of the body-wall varies from
brown to purplish-red depending upon the amount of the red phosphatic
deposits contained in it. The caudal portion, however, is always light
brown in colour, as the calcareous deposits contained in this region do
not change into the phosphatic deposits. The body-surface is slimy and
is more or less rough to touch. It is dotted, except in the caudal region,

with small white spots caused by the rosettes of calcareous deposits.

Encircling the mouth, there are fifteen short tentacles, each having a pair of digitis laterally near the tip, giving the appearance of three digits at the terminal end. The well-extended tentacles of a specimen of 7 cm total body-length measure from 3 to 4 mm. in length, and from 1 to 1.5 mm. in breadth, the digits being about 0.5 mm. long. While the animal is living we can observe through the translucent wall of the tentacles the red fluid flowing in the tentacular canal.

A cone-shaped genital papilla, which is about 1 mm. long, is situated in the dorsal interradius at a point a little behind the tentacular crown. It is not opened to the exterior except in the breeding season, and there is not any difference in size between the male and female papillae.

There is an opening in the stone-canal at a point a little behind the genital papilla, and it is indicated by a small, translucent, circular patch. By means of this opening the stone-canal communicates with the exterior. At the terminus of the caudal portion we find 15 anal papillae, and 5 anal teeth situated at the radii and surrounding the anus.

2.   The body-wall and the musculature

(a) The body-wall (Pl. XII, fig. 12)

The body-wall of the *Molpadia*, as in other Holothurians, consists of (1) an unilaminar body-epithelium with cuticle, (2) a thick connective tissue-layer containing calcareous deposits in its outer portion, (3) an outer circular muscle-layer and five radial longitudinal muscles, and (4) a thin endothelium of the body-cavity.

Through the entire thickness of the connective tissue layer, the " muscle cylinders " run radially at irregular, short intervals starting from the circular muscles, and terminating among the calcareous deposits. Each of the muscle-cylinders is made up of muscle fibres enclosed in a cylinder surrounding a thin connective tissue-core. They never start from the radial water-canals or from radial nerves.

Of these structures SEMPER ('68) recorded, in the cases of *Haplodactyla molpadioides* and *Caudina arenata*, that the muscle-cylinders are actually in connection with the radial canal, and thus he mistook them for rudimentary ambulacral vessels. GEROULD ('96) was inclined to consider that in *Caudina* they might be rudimentary ambulacral vessels, the central ends of which have lost their primitive connection with the radial canal and have secondarily become united with the transverse muscles of

the body-wall. The present writer, however, considers that their function is to serve as a part of the muscular system.

(b) The radial longitudinal muscles (Pl. XI, fig. 4)

The longitudinal muscles run along the five radii in pairs, lying on each side of the radial water canal, to the wall of which they are attached. The anterior extremity of the longitudinal muscle, in the form of a single, tendon-like band, arises from the tip of each of the muscular processes of the calcareous ring and is directed toward the body-wall. The presence of any retractors cannot be detected. The longitudinal muscle abruptly increases its width at the point where the tendon-like band joins the muscle. At the same time the muscle divides into two bands, and a longitudinal furrow is formed between them. This furrow is for the insertion of each of the radial water-canals. At the same time the suspensor muscles which arise from the transverse muscles are attached to the adradial edges of the longitudinal muscle, and later the same kind of muscles are also attached to the, abaxial side of the same. Thus the paired longitudinal muscle-band is attached to the body-wall by means of the suspenders arranged in four rows. The longitudinal muscle-band is also set in connection with the wall of the radial water canal on its interradial edges. Between the paired muscle-bands there may be found a small group of muscle-fibres running longitudinally covering over the radial water-canal, and attached to the axial wall of the same.

Toward the posterior part of the body the paired longitudinal muscles are united together to form a single band, and this time it is suspended from the wall of the radial water-canal only. At the posterior extremity of each longitudinal muscle, it is divided into two groups of fibres. One group of muscle fibres is attached to the base of the anal tooth passing the axial side of the circumnal muscular ring. The other group of muscle fibres is inserted in the anterior wall of the circular anal cavity (text-fig. 20).

(c) The circular muscles

The circular muscles enclose the body-cavity, lying transversely and occupying the five broad interradial area. They are interrupted by the radial nerves at the five radii. Surrounding the anterior processes of the calcareous ring, there exist other kinds of circular muscle-fibres which are uninterrupted and which are embedded in the connective tissue layer of the body-wall. The circular muscles of the body-wall send their fibres here and there toward the connective tissue of the same, forming the muscle-cylinder, and some other muscle-fibres are directed toward the

longitudinal muscles serving as suspenders. At the posterior extremity
of the tail, the cloacal opening is surrounded by a circumnal muscular
ring consisting of a small group of muscle-fibres, and is situated at the
abaxial side of the circular anal-cavity (text-fig. 20, 22).

3. The calcareous deposits

The calcareous deposits in the *Molpadia* may be found in the follow-
ing parts of the body, (1) integument, (2) tentacular wall, (3) stone-canal
and madreporite, (4) muscles, (5) anal teeth, and (6) calcareous ring.

(1) The integument

The calcareous deposits found in the integument may change into
phosphatic deposits with the advancing age of the animal. It is rather
difficult to find out what kinds of deposits exist in the older specimens.
The present observations, with the hope of discovering what kinds of
deposits exist, were chiefly made of younger animals.

The various kinds of calcareous deposits : — There are several varieties
of calcareous deposits, some in the course of development and others
completed. The completed forms may be classified into the following
three groups, viz. (a) tables, (b) anchors, and (c) rackets.

The typical table-form (text-fig. 2) consists of a disc and three spires.
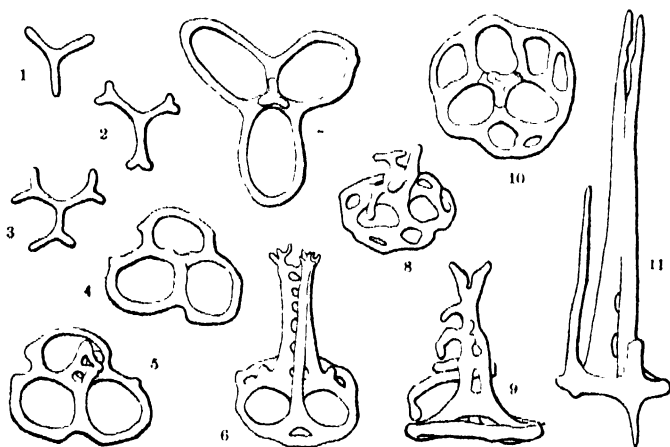
Text-fig. 2. Calcareous deposits found in the body-wall. 1: Y-shaped fundament,
2-5: developing stages of table, 6: typical table, 8-11: irregular tables. ×230

The disc in most cases is perforated with 3 or 6 holes and has an un-
dulating margin, bearing a Y-shaped beam in the centre. The spires

start from the Y-shaped beam, and stand perpendicularly to the plane of the disc, and each terminates usually in three spines. The diameter of the disc measures from 60 to 65 µ while the height of the spires is from 65 to 145 µ.

The tables are abundantly distributed in the integument of the trunk, with the tips of spires projecting from the body-surface. There are also some irregular tables with cross-bars of spires developed to a great length and fused with one another at their tips.

The anchor-forms (text-fig. 3) are provided with two arms, each bearing 2 teeth. The base of the anchor is in the form of a small disc perforated usually with 3 holes. The anchor has a length of 350–400 µ, a breadth of 110–115 µ measuring across both arms, a thickness of 22 µ, and a diameter of 50–57 µ measured at its base. The anchor stands out from the body-surface, from the centre of the so-called rosette, which is formed by from four to seven racket-shaped rods set radially.
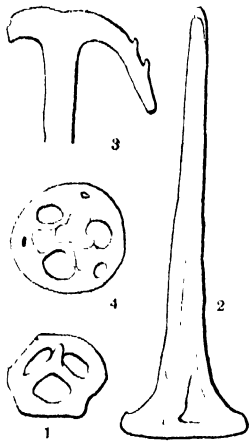
Text-fig. 3. Calcareous deposits found in the body-wall. 1: a calcareous deposit destined to the future anchor, 2: anchor-stem-like deposit, 3: free end of an anchor, 4: base of an anchor. ×230

It is noticeable that there are some deposits each of which looking as though it were a stalk of the anchor above mentioned. The free end of the stalk in most cases is provided with a longitudinal furrow, and is not provided with arms as in the case of the anchor. Of this kind of deposit it may be said that if the tip of the stalk grows into arms, then it will become just same as the ordinary anchor. These anchor-stem-like deposits measure 120–370 µ in length, and the diameter of the base is 60–70 µ. They are sparsely scattered with their long axis placed parallel with the body-surface, and are not found combined with the rosettes. Besides these anchor-stem-like deposits there are various other kinds of irregularly shaped deposits as shown in the text-fig. 2, 11.

There are some fundamental differences in the form of the tables, the anchor and the anchor-stem-like deposits, viz. the spires of the table consist of three rods connected with one another by a number of cross-bars, while in the cases of the anchor and the anchor-stem-like deposits, the three spires are fused to form a single thick rod bearing no cross-bars.

The racket-forms (text-fig. 4) consist of a circular disc with many perforations and a long stem produced from the disc. The free end of
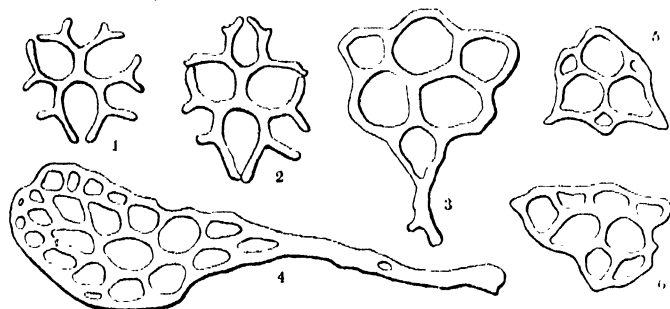
Text-fig. 4. Calcareous deposits found in the body-wall. 1-3: developing stages of a racket, 4: young racket, 5-6: perforated disk. × 230

the stem is usually somewhat enlarged. The total length of the typical racket measures 400–600 μ and the diameter of the disc is 70–100 μ. Three to seven of the rackets are arranged radially, their discs more or less overlapping each other, thus composing a rosette. From the centre of the rosette there arises the stem of an anchor. These groups of calcareous deposits forming rosettes are represented by white spots distributed on the body-surface, and are noticeable even with the naked eye (text-fig. 5). There are some rosettes without an anchor. The rosettes
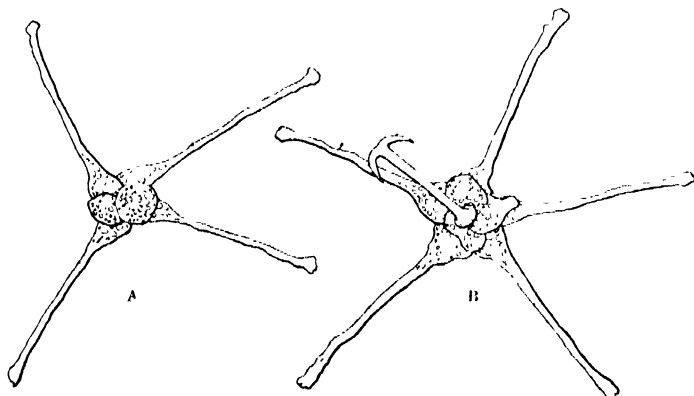
Text-fig. 5 Calcareous deposits forming rosettes in the body-wall. With anchor (B) and without (A). × 50

are found to the number of 21–27 on each 5 square milimeter-area of the body-wall covering the trunk region in fully expanded specimens of

1.5 cm long.   No difference seems to exist between the number of the
rosettes distributed on the dorsal surface and the number on the ventral
surface.   They do not show any regular arrangement.   In a rosette one
or two circular perforated discs may be usually found in addition to the
rackets of ordinary type.   These circular discs have a diameter of 90–100 μ.

In the caudal region there are found deposits of the table-form each
having long prolongations on either side of the disc (text-fig. 6).   They
are found in great abundance overlapping
each other, leaving very small spaces among
them.   This kind of table differs from the
ordinary one, not only in having the pro-
longations of the disc, but in having thicker
discs, and shorter spires projecting from the
discs than in the ordinary tables.   Some of
the deposits found in the caudal region are
provided with three prolongations arising
from the disc.   Concerning the size there
does not exist much difference between
these two kinds of tables.
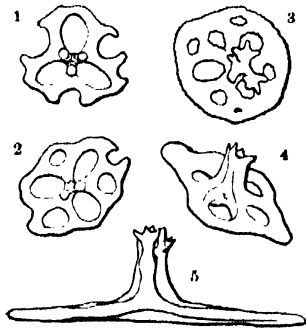
Text-fig. 6.   5 calcareous de-
posits found in the body-wall
of the tail region. ×230

Development : --- In the development of
calcareous deposits in most cases of Holo-
thurians the fundamental form of growth is said to be of X-shape.   But
in the case of *Molpadia* the development is in a three-rayed shape which
I should like to call the Y-shape.   In the case of the present species the
fundamental Y-shaped growth is formed first from the simple rod-like
spicule, measuring about 10 μ in length.   From the central part of the
rod a lateral branch arises and thus forms the shape of the figure Y
(text-fig. 2, 1).   In the early stage of spicular development two sorts of
forms may be distinguished among the Y-shaped spicules, one is flattened
and the other is arched.   The flattened Y-shaped spicules develop in a
horizontal plane and finally become rackets or circular discs.   While the
arched Y-shaped spicules develop not only horizontally but also vertically,
sending out usually three rods from the upper sides near the centres of
the spicules thus becoming either tables or anchors.

When the Y-shaped spicules of both types increase their size, and
each of the arms become 20 to 25 μ long, then a second branching occurs
on each of the three tips.   Each of these six branches thus formed unites
with its adjacent ones forming three perforations of the disc.   From the
margin surrounding these three holes, other six buds are produced

horizontally. The six branches thus formed for the second time again unite with each other at their tips and form a disc with six holes. This developmental process is almost similar in the discs of both the table and the racket.

The spires of the table are first formed vertically from the arched Y-shaped spicule, while the stalk-like prolongation of the racket is produced horizontally from the flattened disc. The spicules forming the table are usually comparatively thick and have smaller holes, whereas these forming the racket are rather thin and have larger holes.

Sometimes discs are found with four holes looking as if they have grown from the X-shaped fundament. But these seem to be abnormal cases (text-fig. 7).

Phosphatic deposits : — The circular or ovoid disc-like corpuscles called " phosphatic deposits " may be found in great abundance among the calcareous deposits in the body-wall, even in the case of the youngest individuals (text-fig. 8). These
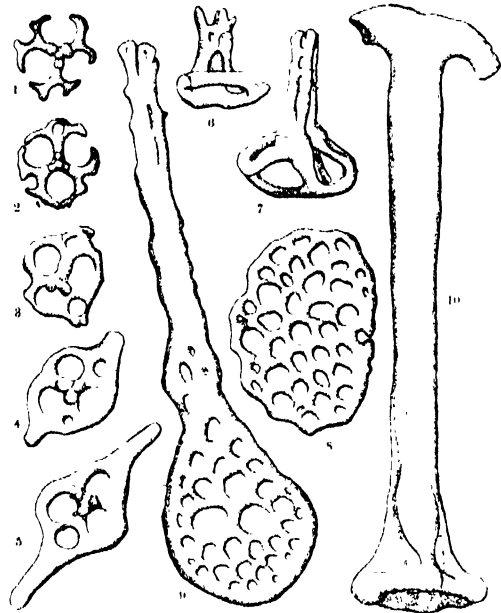
Text-fig. 7. Calcareous deposits found in the body-wall of an old specimen of 12 cm. long. 1–5: tables in the caudal region, 6, 7: tables, 8: disk, 9: racket, 10: anchor. ×180
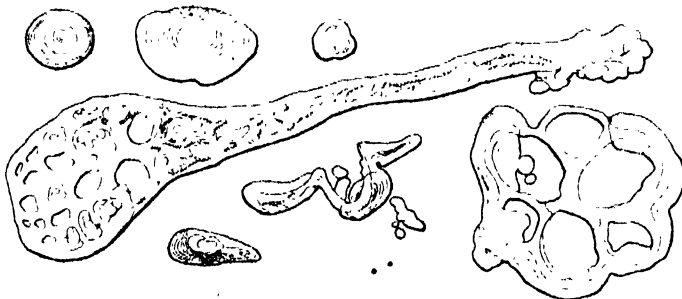
Text-fig. 8. Phosphatic deposits found in the body-wall. ×230

corpuscles are from yellow to brown in colour, and are from 2 to 50 μ in diameter. These bodies appear first, as pale brownish-yellow granules, in the course of changing from calcareous spicules into phosphatic deposits. Each of these bodies grows into a disc showing concentric lines formed around one or two centres.

In the body-wall of the specimens over 6 cm long, calcareous deposits are found very rarely, as the most of the spicules which formerly existed are replaced by the red phosphatic deposits. But in the caudal region even in the case of older specimens, the spicules are not changed into phosphatic deposits, and thus the tail always looks white.

The calcareous tables, rackets, and rosettes, which are partially changed into phosphatic deposits may be found here and there in the body-wall even in the case of young specimens. The spicules forming the calcareous ring, the stone-canal, the madreporite, and the anal teeth seem never to change into phosphatic deposits.

(2) The tentacles, the stone-canal, and the muscles.

The calcareous deposits are rather sparsely distributed in the membrane investing the inner base of the tentacular crown. They are various in shape, being in the form of irregular rods, irregularly branched rods, and irregularly perforated plates, and also are variable in size measuring from 10 to 60 μ in length (text-fig. 9).
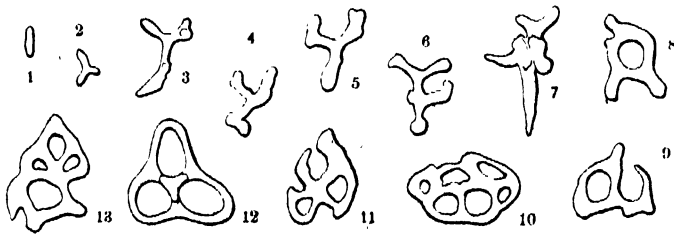
Text-fig. 9. Calcareous deposits found in the tentacular wall. ×230

The stone-canal is furnished through its whole length with a well-developed calcareous frame-work, which consists of thin irregularly branched and more or less convoluted rods, measuring from 70 to 100 μ in length. These spicules are rather thinly distributed near the end attached to the circular water-canal, while in the region of the pore-canal they are arranged so as to form many rings (text-fig. 10).

In some specimens in the interior of the longitudinal and circular muscles, there are found a very few spicules. These spicules are very thick, and are usually partly broken.

Text-fig. 10. Calcareous deposits found in the wall of a stone-canal × 230

(3) The anal teeth (text-fig. 11)

There are five calcareous teeth which are arranged in five radii surrounding the cloacal opening. They are called the anal teeth and are elongated triangular in shape with a large central hole. Each tooth consists of one or two layers of spicules forming a net-work leaving small spaces among them. These five anal teeth are nearly equal in shape and size, measuring 450 μ in length, and 170 μ in width, in the case of a specimen of 15 mm. body length. The base of each anal tooth is embedded in the connective tissue layer of the tail, and is placed between the perianal sinus and the circumnal muscular ring. They are attached to the terminal fibres of the longitudinal muscles of the body. Each tooth projects out from the inner side of the anal papilla passing through the axial wall of the circumnal ampulla (text-fig. 20).

As to the situation of the anal teeth, HEDING ('36, p. 70) states in the case of *Eupyrgus scaber:* — " The anal teeth are placed exteriorly of the radial canal, and the bifid parts of them are placed over the radial canal, in the same manner as the bifid process of the radials in many Molpadids are placed at the origin of the radial canal." But in the case of the *Molpadia* under consideration they are not placed exteriorly, but always interiorly of the radial canal, as above described.

Text-fig. 11. One of the anal teeth of *M. roretzii.* (2.5 cm. long) × 180

4. The calcareous ring

(a) The structure (text-figs. 12 and 13)

The calcareous ring, which forms the frame-work of the so-called aquapharyngeal bulb, encircles the pharynx in the anterior part of the body-cavity. It is composed of ten pieces of calcareous plates, of which five are radialia and five interradialia, alternately arranged, and connected firmly with each other to form a ring.

Text-fig. 12. Calcareous ring of *M. roretzii*, side view. × 7. d: dorsal, v: ventral.

Text-fig. 13. Two calcareous ring roled out flat and opened at the dorsal interradius to show its abaxial surface. × 2.5. A. was taken from the specimen 12 cm. long. B. was taken from the specimen 6 cm. long.

Each interradial piece is somewhat convexed, forming a square plate provided with an anterior process in the middle. The interradialia are nearly equal in shape, but the ventral ones are a little under than the dorsal. On the external surface of the interradial piece there are two longitudinal depressions, one on each side of the median line. These depressions are for the insertion of the tentacular ampulla.

Each of the radial pieces, which is much larger than the interradial piece, has two processes anteriorly, and one long, bifurcated process posteriorly. One of the two anterior processes is called the " muscular process ", and to this process the radial muscle attaches. Through the tip of the muscular process there exists a perforation, serving as the passage for both the radial nerve and the radial water-canal. On the external surface of the radial piece there are found two kinds of

depression, one placed on the median line for the insertion of the tentacular ampulla, and the other situated below the muscular process for the insertion of the anterior part of the radial muscle.

The radialia situated on the right side are identical with those on the left side with regard to the following three points, (1) in the length of the posterior process, (2) in the degree of inclination towards the axis of the calcareous ring, and (3) in the position of the muscular process. The posterior processes of the two dorsal radialia, paired left and right, are the longest of all, and their inclination towards the axis of the ring is most distinct. The posterior processes of the ventral radialia, paired left and right, are intermediate in length between the mid-ventral and the dorsal, and in their inclination towards the axis of the ring. The posterior process of the mid-ventral radialia is the shortest of all and is nearly straight not bending towards the axis of the ring, and is not symmetrical as in other radialia.

Each muscular process of the radialia is arranged, as formerly recorded by LUDWIG ('82–'92, '91) and later by GEROULD ('96), in the following manner, viz. tentacle dorsad, muscle ventrad. That is to say that each muscular process of the two right radialia is situated, if the calcareous ring is opened flat and viewed from the abaxial surface, to the right of the two anterior processes, whereas each muscular process of the two left radialia is to the left. Of the mid-ventral radial either the right or the left anterior process is destined to serve for the attachment of the longitudinal muscle. In 80 out of 100 cases examined the right process serves for the attachment and in the remaining 20 the left process does so. Consequently the number of the tentacles seen in each of the inter-radii, is different in accordance with the position of the interradii. In the dorsal interradius there are always 4 tentacles, while in the left and right ventral interradii there are 3 and 2 tentacles respectively, though occasionally there are 2 and 3 respectively. Thus each of the remaining two interradii posesses 3 tentacles (Pl. XI, fig. 1, 2).

On the axial surface of each of the five radialia there exists a longitudinal furrow for the insertion of the radial canal which runs along the median line. This furrow arises from the bifurcated tip of the posterior process and extends to the perforation of the muscular process. Three other branches for the insertion of tentacular canals issue from the anterior part of this furrow. Of these branches of the furrow the one for the radial canal has a calibre much smaller than that of the tentacular canals. The manner in which the canal branches is illustrated in text-fig. 14.

The dry weight of the whole calcareous ring is 55 mgr. in the case of a specimen of about 8 cm body length.

r.d.r.   r.v.r.   m.v.r.   l.v.r.   l.d.r.
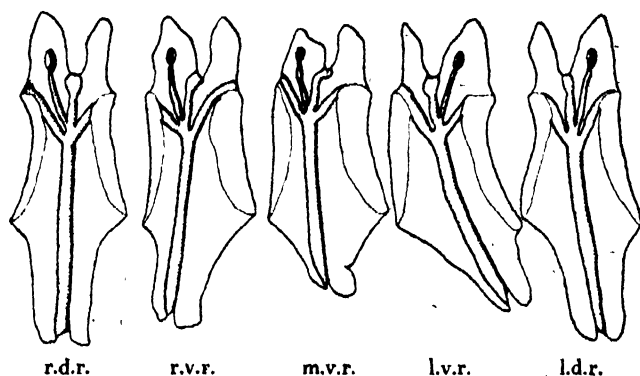
Text-fig. 14. Five radialia of the calcareous ring, roled out flat showing its axial surface, along which the radial canals branch. ×4

Here I wish to allude to the manner in which the five radii are placed in relation to the principal axis of the body in the *Molpadia*. Each muscular process of the calcareous ring, which gives rise to the radial muscle, radial nerve, and radial canal may be taken as to representing each radius. Thus if the distances between two muscular processes are measured in five interradii, the manner in which each radius radiates will become clear. Under the above consideration the distances between the muscular processes were measured in eleven cases of the calcareous ring, each having the muscular process of the mid-ventral radialia on the left side. Measurements were also taken in four other cases, in each of which the muscular process was found on the right side. The distances between

TABLE I

	Mid-dorsal interradius	Right-dorsal interradius	Right-ventral interradius	Left-ventral interradius	Left-dorsal interradius
The number of tentacles arranged in each interradius	4	3	3	2	3
The distance between each interradius shown in percentage	25.32±.1675	20.15±.0908	20.05±.0673	14.25±.1179	20.27±.0812
The central angles formed around the principal axis	91.1°	72.5°	72.1°	51.3°	73.0°

the interradii of the calcareous ring were expressed in percentage to the length shown by all these distances combined. And from the above results, the central angles, which are formed around the principal axis and which are facing each interradius, were obtained. These results are manifested by their mean values together with the probable errors, as shown in the following table (TABLE I). In the remaining four cases the same tendency is also seen, except that the right ventral interradius is replaced by the left ventral interradius.

Judging from these facts, and also from the facts which will be referred to in paragraph 6 discussing the water vascular system, it seems that there exists in the *Molpadia* neither radial symmetry nor bilateral symmetry regarding the radiating manner of the radii (text-fig. 16).

(b) The constancy of the calcareous ring
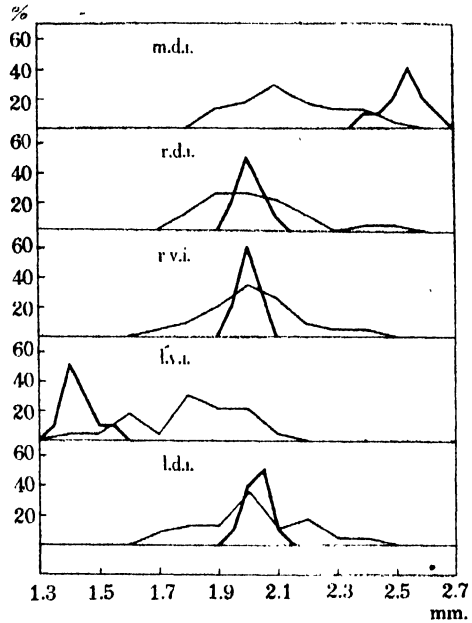
Text-fig. 15. The fat lines shows the frequency distributions of the distances between the two muscular processes of the calcareous ring. The slender lines show the frequency distributions of the distances ($^1/_{10}$) between two radial canals in the level where the body-wall is the broadest.

A B
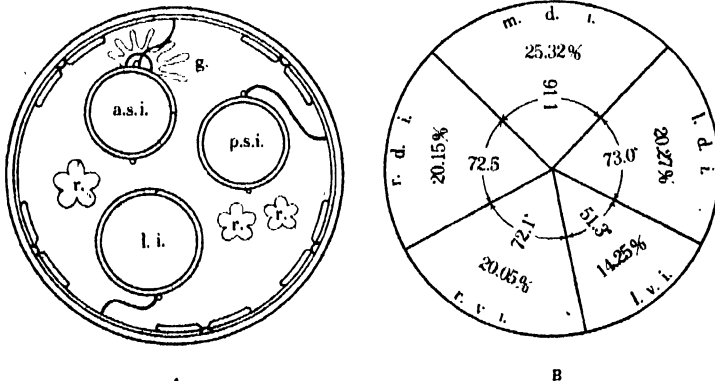
Text-fig. 16. A. Diagramatic figure to show the cross-section of the body of *M. roretzii*. (oral view). B. Diagram illustrating the radiating manners of five radii.

Concerning the calcareous ring CLARK ('35) states, " In the larger
Molpadiidae the addition of calcareous material to the calcareous ring
continues in variable amount throughout life. Reabsorption and redis-
position go on hand-in-hand, and increase in size is often, if not always,
accompanied by change in form and in the proportion of the various
parts." Thus he thinks that the calcareous ring affords no definite
characteristics which are to be used in distinguishing the species.

On the contrary HEDING ('31, '35) pays much attention to the shape
of the calcareous ring and emphasizes its value in classifying the *Molpadis*.
He drew attention to the following three points: (1) the relative length
of the five posterior processes, (2) the features of the passage for the
radial nerve found in the muscular process, (3) the furrows for the inser-
tion of the tentacular-muscles and the tentacular ampullae. And he ('35)
states that, " Contrary to OHSHIMA's opinion is that of the present author,
who has found, in spite of the often rather specific variation of the
calcareous ring, that the shape of this organ is in the strongest correlation
with the systematic place of the specimen. A correlation which is not
alone specific but also generic, and even the two families *Molpadiidae*
and *Caudinidae* may be separated by the mere apperance of the calcareous
ring."

Now it is necessary to examine many individuals in order to ascertain
whether there exists any constancy or not in the shape, of the calcareous
ring. It is desirable to make clear first the individual variations of the
pieces forming the calcareous ring, and secondly to know their mutual
relation in position, and thirdly the relation in size of the radialia and
the interradialia.

As to the relative position of the anterior process, it may be thought
that there exists some constancy judging from the facts shown in the
table I (text-fig. 15). Since the relative position of the anterior processes
thus became clear, there is no further need to allude to the relation in
position of the radialia. With the purpose of confirming the relationship
in shape and size of each piece of the calcareous ring, two radialia and
one interradialia have been examined. The relative length of the radialia
is an important fact on account of the habit of the living animal of
burying itself in the mud.

The growth-rates of both the left-dorsal radialia and the ventral
radialia are shown in the text-fig. 17, recording the distance between the
two anterior processes in abscissa, and the height measured from the tip
of the muscular process to the end of the posterior process in ordinate
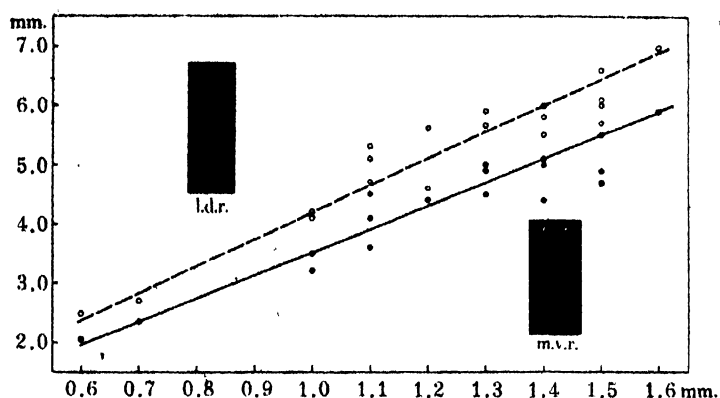
Text-fig. 17. The growth rates of the left-dorsal radialia is shown with broken line and that of the ventral radialia with the full line.

(text-fig. 17). This shows that each radial increases in size whithout greatly changing its shape. The text-fig. 18 shows the comparison of the heights of the left-dorsal and of the mid-ventral radial in the growing animals. The dorsal radialia are $1.286\pm.00963$ times high when compare with the ventral radialia in the case of the present species. Thus the difference in height of the radialia is recognised to be one of the fixed characteristics in the calcareous ring of the *Molpadia*. And also the growth rate of the heights of each of the two interradialia of the dorsal (in abscissa) and the left-ventral (in ordinate) are shown in the text-fig. 19.
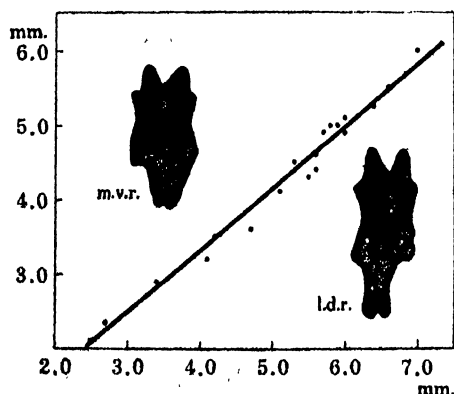
Text-fig. 18. The comparisons in heights of the left-dorsal (in abscissa) and the mid-ventral radial (in ordinate) in the growing calcareous ring.
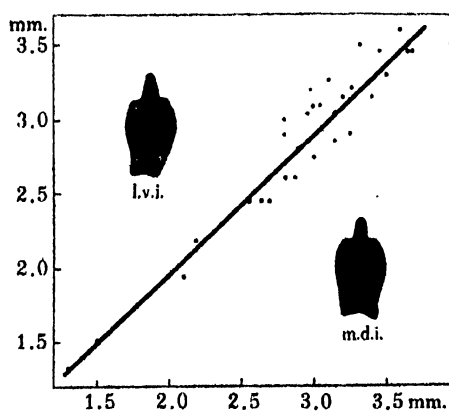
Text-fig. 19. The comparisions in heights of the mid-dorsal (in abscissa) and the left-ventral (in ordinate) interradial in the growing calcareous ring.

This indicates that the relationship of the heights shown by the said two interradialis is fairly constant.

The width of each interradial shows only a little growth compared with that of the height. So that the interradial separates the two radialia more widely in the smaller calcareous ring than in the case of the larger ones. In the larger calcareous ring the interradialia are rather narrow being of wedge shape. The same facts have been already discussed by HôZAWA ('28) in the case of *Paracaudina*.

5. *The nervous system*

(a) The circular nerve ring

The circumoral nerve ring which is superficial in position, lies immediately internally at the base of the tentacles, and just anterior to the calcareous ring (Pl. XI, fig. 3). The axial side of this nerve ring lies close to the abaxial wall of the peribuccal sinus, and the anterior margin is covered by a loose connective tissue-layer, and the greater portion of its abaxial side lies next the tentacular muscles and the anterior processes of the calcareous ring. The cross-section of the circumoral nerve ring is in most cases elliptical, but it is sometimes circular or elongated oval. Around the anterior margin of the nerve-ring there is a narrow but deep furrow for the insertion of the circular epineural canal.

(b) The radial and the tentacular nerves

Each of the five radial nerves, which radiates from the nerve ring along each radius, passes through the perforation of the radial plate of the calcareous ring together with the radial water canal (Pl. XI, fig. 3). The radial nerve runs backward being embedded in the connective tissue-layer of the body-wall (Pl. XII, fig. 11) and is divided posteriorly into three branches distributing on the abaxial wall of the anal papillae (text-fig. 20). Each of the radial nerves consists of two bands separated by a thin layer of connective tissue, viz. the thick outer band and the thin inner band (Pl. XI, fig. 5). The former is crescentic in cross-section and is covered by the epineural canal all over its abaxial side. The latter is placed close to the former, and its axial wall is protected by the hyponeural canal which is attached to the abaxial wall of the radial water-canal. The inner band of the radial nerve starts in the form of a string formed of nerve-cells at a point immediately posterior to the junction of the outer band with the nerve ring. It shows a median furrow in the anterior part of its axial surface. It terminates prosteriorly in

front of the circumnal ampullae
and is not jointed with the terminal
branches of the outer band.

Each of the fifteen tentacular
nerves arises radially from the
outer posterior portion of the nerve
ring in the form of a sheet and
runs upwards along the median
furrow formed on the axial side
of the tentacular muscle (Pl. XII,
fig. 7).

The basal portion of the ten-
tacular nerve, which is thick and
crescentic in cross-section, is covered
by the epineural canal. Each of
the tentacular nerves gives off
many branches around the tentacle
and thus it gradually diminishes in
width and in thickness toward the
tip.

(c) The hypo- and the epi-
neural canals

Fig. 20 Longitudinal section of the tail
end at the radius. × 120. ap: anal papilla,
at: anal tooth, bc: body cavity, ca: cir-
cumnal muscular ring, ec: epineural canal,
hc. hyponeural canal, hg. hind gut, lm
longitudinal muscle, ps: perianal sinus, rc-
radial canal, rn radial nerve.

The hyponeural canal arises just behind the attachment point of each
inner band of the radial nerve to the nerve ring, and runs backwards
covering the whole axial side of the inner band. (Pl. XI, fig. 5). Pos-
teriorly it terminates blindly being combined with the posterior end of
the inner band (text-fig. 20). As the inner band attaches to the outer
wall of the circumnal ampulla, there is no room for the hyponeural canal
to advance further, and also there is no communication with the circumnal
ampulla. So that in any case the hyponeural canal must be a blind tube
running along the axial wall of the radial nerve.

The circular epineural canal lies anterior to the nerve ring, its anterior
portion inserting itself into a furrow surrounding the nerve ring. Each
radial epineural canal, which arises from the said circular canal runs
together with the outer band of the radial nerve along its abaxial side
(text-fig. 20). It terminates blindly together with each end of the radial
nerve, and does not communicate with the radial water-canal. The ten-
tacular nerve also has the epineural canal on the axial side of its basal
portion, as already referred to.

6   The water-vascular system

(a) The circular canal and the Polian vesicle (Pl. X)

The circular canal surrounds the oesophagus just behind the calcareous ring, forming a festoon fastened at each interradius. From the circular canal at each radius, there arises the radial canal which runs upwards inserting itself into the furrow found on the axial side of each radialia of the calcareous ring. The axial wall of the circular canal is supported by means of many strands arising from the oesophageal wall, while its posterior margin is attached to the wall of the perioesophageal sinus. The canal measures 0.5 mm. in diameter in a specimen of 6 cm. body-length, and has a thin, translucent wall, through which the red fluid contained inside it is visible from the outside.

The Polian vesicle is an elongated oval sac measuring 5 7 mm. in length and 1 2 mm. in thickness in the case of a specimen of 6 cm. body length. It is generally attached to the circular water-canal in the left ventral radius contrary to conditions obtaining in other *Molpadids* in which the Polian vesicle is said to be in the left ventral interradius. Thus the attached end is somewhat enlarged and communicates with the left dorsal and the left ventral interradii of the circular canal. The wall of the Polian vesicle resembles that of the circular canal, but when it is examined in section the layer of circular muscle fibres is comparatively thick and it seems to operate to a certain extent the contractions and relaxations. At its opening leading into the circular canal, no valves or any other organs are found to regulate the stream of the fluid. The interior of the vesicle is filled up with red blood corpuscles and attached to its inner wall there are some black spherical bodies. These black bodies exist also in the interior of the perioesophageal sinus and are observable from outside.

(b) The stone-canal, the madreporite, and the pore-canal

The stone-canal, which arises from the circular water-canal in the centre of the dorsal interradius, is suspended dorsally by the dorsal mesentery and runs forwards and upwards taking a sinuate course and reaching the body-wall in a point located at the dorsal interradius. It carries a madreporite near its anterior end, and its distal portion forms a short pore-canal leading to a pore, which opens to the exterior, piercing the body-wall at a point a few mm. behind the gonoporus (Pl. XII, fig. 8). The total length of the stone-canal is about 6.5 mm. and its diameter is about 0.2 mm. in the case of a specimen 8 cm. long. The inner wall of this

canal is ciliated especially on one side. The stone-canal and the pore-canal are furnished with many spicules as already mentioned. A small area of the body-wall surrounding the opening of the pore-canal is deprived of both of calcareous and phosphatic deposits.

The madreporite, roughly speaking, is a heart-shaped body containing inside many branched calcareous bodies, and the outside is covered all over by a ciliated epitherial layer. The madreporic body contains a central chamber which is connected with the stone canal, and furthermore with the pore-canal, and opens to the body-cavity by means of many canals piercing the thick wall of the madreporite and taking an undulating course (Pl. XII, fig. 8). At the end of the stone-canal and of the pore-canal, there no equipment found to regulate the blood-stream. The blood corpuscles, however, can be found in great abundance not only in the stone-canal and in the madreporite, but also in the pore-canal.

(c) The radial canal

The radial canals, which arise from the top of the undulating festoon of the circular canal, run at first anteriorly along the furrows made on the axial surfaces of the radialia. After giving off three branches to the tentacles, each of the radial canals becomes thinner and passes through the perforation found near the tip of the muscular process. The radial canal, which has passed through the perforation above mentioned together with the radial nerve, reaches the body-wall and then runs backwards along each radius till it attains the tip of the tail. The radial canal is situated between the paired longitudinal muscles, and its abaxial wall is attached to the hyponeural canal (Pl. XI, fig. 5). At the posterior extremity of the body the radial canal is divided into three branches, each

Text-fig. 21. Cross-section of the anal papillae at the end of the radial canal × 240. ap: anal papilla, ca: circumnal ampulla, cm: circumnal muscular ring, ec: epineural canal, prc: posterior branch of radial canal, ps: perianal sinus, rn: radial nerve.

ending blindly in the form of an oval sac and representing the inner wall of the anal papilla (text-fig. 21). Of these branches the central one

is the largest and is called the circumnal ampulla, while the lateral two are usually smaller, and are sometimes rudimentary. Fig. 22 was prepared by means of the reconstruction of serial sections, and it shows the outer wall of these three branches of the radial canal.
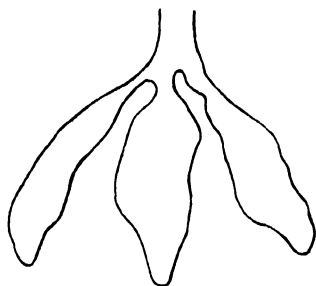
Text-fig. 22. Graphic reconstruction of the anal papillae, viz. the end of the radial canal. ×120

Whether the manner of the radiating of each radius differs in the anterior portion from the remaining portion or not, it is necessary that this should be made clear in this case. With the purpose of ascertaining the above facts, the distances between each radial canal were measured in the region where the body is broadest. The specimen used were 30 in number and they were all treated under the same conditions. The midventral radials were observed being placed in exactly the same manner as in the case of calcareous ring, one having its muscular process in the right side and the other in the left. The results obtained by the method above stated were expressed by the mean value of the percentage to the whole length surrounding the trunk and also by the angles formed in the centre facing each interradius (TABLE II). It was proved that the radiating manner of each radius in the body-wall, observed in the broadest portion of the trunk, showed the same tendency as that shown in the anterior portion of the same. There exists some difference between the mid-dorsal and the left-ventral interradii, and it has a statistical significance.

TABLE II

	m.d.i.	r.d.i.	r.v.i.	l.v.i.	l.d.i.
Each width to the whole (mean %)	$21.36 \pm .220$	$20.30 \pm .223$	$20.11 \pm .262$	$17.99 \pm .221$	$20.14 \pm .233$
Each angle at the centre	$76.9°$	$73.1°$	$72.4°$	$64.8°$	$72.5°$

(d) The tentacular canal (Pl. XI, fig. 2, 6)

Each of the tentacular canals arises from the radial canal at a point located in the anterior of the axial surface of the calcareous ring. An-

teriorly the tentacular canal is divided into three branches corresponding to the three digits of each tentacle. Of these branches the central one is divided again into two compartments by a thin membrane set radially and attached by its base to the inner wall of the central digit. Thus the tentacular canal is divided anteriorly into 4 compartments. The arrangement of the tentacular canal in relation to the calcareous ring has been already recorded.

Each tentacular canal bears posteriorly a·tubular outgrowth which is called the tentacular ampulla. It inserts itself into the depression found on the outer side of the calcareous ring, and projects freely backwards in the body-cavity in the form of a blind sac. It is 8–9 mm. long, and 1–2 mm. broad. The tentacular wall is furnished with a well-developed longitudinal muscle-layer which covers it from the tips to the anterior part of the ampulla. It is attached firmly, with its base on the margin of the depression of the calcareous ring.

7. The coelom

(a) The body-cavity

The body-cavity occupies the whole of the space found inside the cylindrical body. In the body-cavity there are found the viscera and the coelomic fluid containing corpuscles of various kinds. The spacious body-cavity is divided by the mesenteries which arise from the body-wall, and from which suspend the viscera. In the posterior part of the body-cavity, at the ventral side of the cloaca, there exist numerous spherical brown-black bodies measuring 0.3–2.0 mm. across. They are suspended by the muscle strands connecting the cloacal wall with the body-wall. Each of these bodies contains two or three white colored spherules. These spherules are filled up with pear-shaped granules which might be a kind of Gregarinan. The same parasites are found also in the perioesophageal sinus.

As to the coelomic corpuscles found in the body-fluid of the Molpadia OHUYE ('36) has already made a histological study of them. So that the present author does not intend to deal with them here.

(b) The mesenteries (text-fig. 23)

(1) The dorsal mesentery: — The line of attachment of the dorsal mesentery to the alimental-canal begins anteriorly to the dorsal wall of the oesophagus, and it runs backwards along the left side of the dorsal blood-vessel, and terminates posteriorly at the bent part of the small

intestine. The line of attachment of the same to the body-wall begins anteriorly in the middle part of the dorsal interradius lying beneath the genital duct. It turns towards the right side of the dorsal interradius, and runs backwards along the dorsal side of the right dorsal longitudinal muscle, terminating in the body-wall at a point situated at the level of the cloaca. By means of the dorsal mesentery, the genital duct, the stone-canal, and a part of the respiratory tree are attached to the body-wall.

m.d.i. l.d.i. l.v.i. r.v.i. r.d.i.
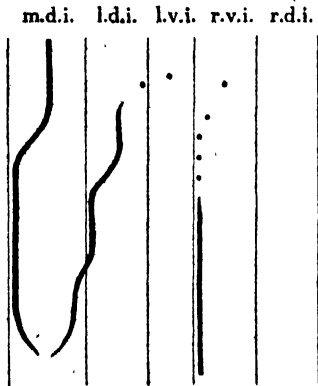
Text-fig. 23 Diagramatic figures to show the line along which the mesentery is attached to the body-wall. The body-wall was opened at the right dorsal radius.

(2) The left mesentery : — The line of attachment of the left mesentery to the alimental-canal begins posteriorly to the first portion of the posterior small intestine and runs upwards along the ventral side of the dorsal blood vessel, and terminates at the hind end of the posterior small intestine. The line of attachment of the left mesentery to the body-wall begins posteriorly in the dorsal interradius at the level where the dorsal mesentery terminates, and runs anteriorly, crossing over the left dorsal muscle. It runs upwards along the ventral side of the said muscle, and terminates in the middle part of the left dorsal interradius.

All these membranous mesenteries when observed in section consist of two connective tissue-layers enclosing a number of muscle fibres between them. Each mesentery is dotted with numerous, minute black spots, and is perforated by many large holes.

(3) The ventral mesentery : — Two muscle-strands arise at the anterior part of the body-wall, one from the dorsal side of the left-ventral longitudinal muscle, and the other from the middle part of the left-ventral interradius. After running a short distance they unite together to form a single strand from which suspends the beginning part of the large intestine. From another muscle-strand, which arises from the middle part of the right ventral interradius, the bent part of the large intestine suspends. The line of attachment of the ventral mesentery to the body-wall is represented first by a dotted line formed by the attachment bases of the muscle strands to the body-wall, and afterwards by the line formed by the ordinary membranous mesentery running along the right side of

the median-ventral longitudinal muscle. The posterior part of the ventral mesentery forms a thick muscle band, fastening the posterior part of the large intestine to the body-wall. Numerous muscle-strands which come out from the interradial part of the body-wall fasten the cloaca to the body-wall in the caudal region. The oesophagus, as in the case of the hind-gut, is attached to the calcareous ring by suspenders which arise from the lateral sides of the radialia and are arranged in longitudinal rows.

(c) The peribuccal and the perianal sinus

The mouth is surrounded by a canal which is circular in form, and which is called the peribuccal sinus (Pl. XI, fig. 3). It is entirely separated from the peripharyngeal cavity by a muscular membrane. The muscular membrane is attached on one side to the inner side of the tentacular muscle, and on the other to the outer wall of the pharynx. Blood corpuscles may be found in the sinus, though the latter has no direct communication with the body-cavity.

The general body-cavity is cut off at the tail end by a small coelomic sinus, called the perianal sinus surrounding the cloacal opening (text-fig. 20). The anterior wall of this sinus consists of a thick connective tissue which is intruded by the terminal fibres of the longitudinal muscles. The perianal sinus also has no communication with the body-cavity, or with the radial canals, but there are found a number of corpuscles in this cavity.

(d) The perioesophageal and axial sinus

The greater part of the oesophagus occupying the area extending from the circular water-canal to the anterior part of the stomach, is covered by a narrow space called the perioesophageal sinus (Pl. XII, fig. 10). The circular water-canal lies at the anterior end of this sinus, and the axial organ runs longitudinally along the dorsal wall of the sinus being connected with the genital organ (Pl. XII, fig. 9). Interior of the sinus there are seen numerous brown-coloured spherical bodies projecting from the outer wall of the oesophagus (Pl. XI, fig. 10). The perioesophageal sinus is provided with a canal communicating with the circular lacunae of the stomach. This canal arises from the posterior margin of the sinus, and is attached to the dorsal mesentery.

The circular water-canal has attached around its axial wall an organ consisting of a net-work of connective tissue. This organ gives rise to a tube from its dorsal portion, at a point just beneath the junction of the stone-canal with the circular water-canal. This tube runs backwards

along the dorsal wall of the perioesophageal sinus, and is suspended by
the dorsal mesentery (Pl. XII, fig. 10). The same tube runs for a short
distance together with the gonoduct, and posteriorly it connects with the
connective tissue lying at the base of the genital organ. This organ may
be regarded as the rudiment of an axial organ as HEDING ('35) states.
In the cross-section cut through the anterior portion of the animal in the
level of the oesophagus, another canal may be found between the gonoduct
and the dorsal wall of the organ above alluded to (Pl. XII, fig. 9). This
canal arises from the wall surrounding the distal part of the axial organ,
and anteriorly it terminates blindly underneath the circular water-canal.
The same canal has posteriorly an opening communicating with the body-
cavity, but it is doubtful whether it should be considered as the rudiment
of an axial sinus.

8. The digestive system

The alimentary canal takes a winding course as is considerably longer
than the body length. Arising from the mouth which lies at the anterior
end of the body, the first part of the alimentary canal representing the
pharynx, the oesophagus, the stomach, and the anterior small intestine
runs backwards, and the second part representing the posterior small
intestine takes a course directed upwards, and the third part representing
the large intestine and the cloaca again runs backwards terminating in
the anus. To the mesenteries from which suspend the whole alimentary
canal, allusion has already been made.

(a) The mouth, the pharynx, and the oesophagus

The mouth leads into the pharynx, which passes the centre of the
tentacular crown, and its entrance is surrounded by the wall of the peri-
buccal sinus. When the tentacles are retracted, the mouth is entirely
closed by their tips. When the body of the animal is fully contracted,
the mouth is hidden within the anterior part of the body, and the re-
tracted tentacles are not seen from the outside.

The pharynx passes through the centre of the calcareous ring, and
from each of the radialia of the ring it receives the suspenders arranged
in two longitudinal rows. These suspenders are attached to the outer
wall of the pharynx (Pl. XI, fig. 2). The pharynx becomes narrower
posteriorly, and joins the oesophagus. The junction of pharynx with the
oesophagus is provided internally with a number of transverse ridges, as
well as the longitudinal ones formed by the inner epithelial wall. As

the oesophagus is suspended from the dorsal mesentery, it bends towards the right dorsal radial muscle apart from the principal axis of the body. The outer wall of the oesophagus is surrounded by the perioesophageal sinus, which extends from the circular water-canal to the anterior part of the stomach (Pl. XII, fig. 10).

The wall of the pharynx consists of four layers, viz. (1) an outer epithelial layer, (2) a circular muscle layer (3) a thick connective tissue layer (4) a columnar epithelial lining. In the oesophageal wall a longitudinal muscle-layer joins the four layers above stated, lining the inner side of the circular muscle-layer.

(b) The stomach and the small intestine (Pl. X)

The stomach, which follows the oesophagus, increases greatly in calibre after passing through a narrow constriction of the alimentary tube. The inner wall of the stomach is provided with numerous fine ridges, which may be easily distinguished from those of the oesophagus. The stomach is attached to the basal portion of the genital organ on its dorsal side leaving a narrow cavity of the perioesophageal sinus between (Pl. XII, fig. 9). The posterior part of the stomach is not provided with the sinus mentioned above and the wall consists of six layers, a thin connective tissue-layer which arises from the wall of the sinus being added to the 5 layers seen in the case of oesophagus.

After passing through the narrow constriction, the stomach leads into the small intestine. The anterior small intestine is suspended by the dorsal mesentery, while the posterior is suspended by the left mesentery. This part of -the intestinal canal is more or less undulated on its ventral side, and has a wall much thinner than that of the stomach. It is provided with numerous fine transverse ridges distributed all over the inner surface of the epithelium.

In the intestinal wall a thick connective tissue-layer is separated from the longitudinal muscle-layer, leaving a narrow space. In the space thus formed there appear so-called lacunae promoting the circulation of the blood. The lacunae extend farther, even into the posterior part of the stomach, and from there they pass by means of a narrow canal into the perioesophageal sinus.

(c) The large intestine, the cloaca, and the anus

The second part of the alimentary tract is narrowed posteriorly and joins the large intestine which forms a part of the third part of the same. The inner wall of the large intestine is provided with longitudinal ridges extending even as far as the cloaca. The wall of the large intestine

consists of five layers, viz. (1) an outer layer. of peritonial epithelium, (2) a thin outer layer of connective tissue, (3) a layer of muscle-fibres, of these muscle-fibres the external ones are circular, and the internal are longitudinal, (4) a thick inner layer of connective tissue, and (5) the columnar lining of the epithelium. The connective tissue-layer (No. 2) of the large intestine is rather loose, and is not compact as is this layer in the case of the small intestine. Many unicellular parasites are found attached to the inner epithelial lining in the anterior part of the large intestine. They measure 130μ in length and 30μ in width, and are found almost without exception in every specimen.

In the cloacal region the alimentary canal occupies again the central axial part of the body. The cloaca gives rise to two respiratory trees on both sides of its anterior dorsal wall. Posteriorly the calibre of the cloaca diminishes gradually. In structure the cloacal wall does not differ much from that of the large intestine above alluded to, but the connective tissue-layer is thinner. The Cuvierian organ is not found in this species. The fully opened anus is round in shape, measuring 2-3 mm. in diameter, and is provided with 5 anal teeth situated inside the anal papillae at the five radii. The anal aperture is surrounded by the wall of the. perianal sinus as already mentioned.

9. The respiratory tree

The respiratory tree consist of two translucent, blind tubes bearing numerous short branches. They arise separately from either side of the median dorsal line in the anterior part of the cloaca.

(a) The right respiratory tree

The right respiratory tree runs forward as far as the aquapharyngeal bulb, being suspended by a number of fine muscle strands, which arise from both the marginal parts of the right-ventral interradius. It is provided with numerous branches which are found especially abundant in the middle part situated between the large intestine and the anterior small intestine. The theory that these branches of the respiratory tree have a connection with the rete-mirabile of the blood vascular system can not be upheld when their mutual position is considered. The terminal end of the respiratory tree is divided into two branches in front of the right dorsal radialia of the calcareous ring, and these surround the posterior part of the calcareous ring. These branches are fastened to each of the posterior processes of the radialia by means of fine muscular strands.

(b) The left respiratory tree

The left respiratory tree is on the whole smaller, but is more copiously branched than the right. It gives off near its base a ventral tree which is not longer than one third of the left tree, and is situated on the dorsal side of the large intestine terminating blindly. The main trunk of the left tree extends farther towards the ventral side of the left mesentery, and numerous short branches project from it into the body cavity. The left tree attains to about two thirds of the height of the right tree, and is fastened by means of the muscle strands to the body-wall. The wall of the respiratory tree consists of the same kinds of layers as shown in the case of the large intestine.

10. The blood vascular system

The lacuner system occupies the interstitial spaces found between the muscle layer and the connective tissue-layer of the alimentary canal. These lacunae spread around the intestinal wall, extending from the posterior part of the stomach to the end of the small intestine. The blood circulated in the lacuner system is finally collected into two vascular trunks. These two vascular trunks in most cases run along the small intestine, one being found on the axial side and the other on the abaxial. From the anterior extremity of the lacuner system there arises a canal which is copiously divided to form a vascular net-work. This canal runs anteriorly towards the perioesophageal sinus along the basal line of the dorsal mesentery. It is by means of this canal that the blood vascular system of the genital organ receives its blood from the intestinal lacunae. The canal opens also on the dorsal side of the perioesophageal sinus. The lacunae situated in the region of the anterior small intestine contain within their spongy structure many masses of eosinophilous plasma with a few nuclei. The blood corpuscles whose cytoplasma closely resemble the said plasma, are found together with the eosinophilous plasma in the connective tissue layer. It seems highly probable that these masses of plasma are to be regarded as the formative cells of the blood corpuscles. The lacunae have free communication with so-called rete-mirabile formed by the blood vascular system. The lacunae situated in the region of the posterior small intestine are composed of fairly thick blood vessels containing numerous blood corpuscles within, but anteriorly these vessels diminish in calibre and at last terminate in the large intestine.

The dorsal blood-vessel arises dorsally from the lacuner system at

the point corresponding to the height of the posterior part of the stomach,
and runs along the abaxial side of the intestine, terminating in the anterior
part of the large intestine. The rete-mirabile is a rich plexus of blood-
vessels situated on the anterior small intestine. The numerous blood-
vessels forming the rete-mirabile are issued at short intervals from the
dorsal blood-vessel. The left border of the rete-mirabile is made up of
a vessel formed by the combination of the smaller vessels of the plexus.
This vessel runs directly towards the middle part of the posterior small
intestine, passing through the body-cavity, and then joining with the
dorsal vessel found there, after running a short distance close to and
parallel with this vessel.

The ventral blood-vessel arises ventrally from the lacuner system at
the same level at which the dorsal blood-vessel arises, and runs along
the axial side of the small intestine but does not extend beyond the
large intestine. It has three (or rarely four) big commisures connecting
the anterior part of the ventral vessel with the posterior part of the same.

The circular blood-vessel, and the radial blood-vessels, in the *Molpadia*
do not show any marked peculialities in feature. The former is represented
by a organ in the form of a circular canal, consisting of a net-work of
connective tissue. It attaches to the axial side of the circular canal and
is connected posteriorly with the so-called axial organ. The latter which
arise from the former, run in company with the radial water-canals being
attached to their axial sides in the peripharyngeal cavity (Pl. XI, fig. 1, 3).
In the body-wall each canal lies between the hyponeural canal situated
on the outer and the radial water-canal situated on the inner side. Here
it has a somewhat hollow structure, but it is too narrow as a passage
for the blood corpuscles (Pl. XI, fig. 5) (Pl. XII, fig. 11). It terminates
blindly at the tail-end, and does not advance farther into the anal papillae.

11. The genital organ (Pl. X)

The gonad consists of tufts of genital tubules forming two groups,
lying on the either side of the dorsal mesentery. The tubules branch
dicotomously, and some of them extend as far as the posterior part of
the body-cavity. The basal portion of the gonad, where all the genital
tubules are gathered, is attached to the dorsal side of the stomach leaving
a cavity of the perioesophageal sinus (Pl. XII, fig. 9). The connective
tissue surrounding the basal portion is continuous with the axial organ
as already mentioned.

From the basal portion of the gonad, the genital duct runs forward being suspended by the dorsal mesentery and reaches the genital papilla. The cone-shaped genital papilla lies immediatly behind the tentacular crown in the dorsal interradius. In ordinary use this papilla does not seem to be opened to the exterior, as the aperture is closed by a thick mass of connective tissue. But in the breeding season an aperture is formed and thus the sexual elements are emitted through it. The sexes are separate in this animal. The male genital organ may be distinguished from the female by its colour. Especially it is clear at the time of sexual maturity. The male organ is white-yellowish in colour, while the female is reddish yellow. The breeding season is considered to occure in the early winter, perhaps in November or in December.

V. SUMMARY

1. The anatomy of a Holothurian, *Molpadia roretzii* (V. MARENZELLER) is dealt with in the present report. Together with the morphological study, some ecological observations have also been made to some extent.

2. Of this animal the spicules found in the body-wall originate from a triply radiating body, which is named the Y-shaped fundament.

3. All the calcareous deposits are changed into phosphatic substances with the advancing age of the animal.

4. The anal teeth which seem hitherto to have been insufficiently studied in the *Molpadids*, are dealt with more or less in detail in describing the present species.

5. Special attention is paid to the shape and structure of the calcareous ring taking its value into consideration from the view point of systematics. The shape of the calcareous ring seems to be fairly constant in the case of the *Molpadia roretzii*.

6. The radiating manner of the radii are examined in two cases, viz. those of the calcareous ring, and those of the body-wall. There exists in *Molpadia roretzii* neither the radial symmetry nor the bilateral symmetry regarding the radiating manner of each radius.

7. The fluid contained within the water-vascular system may flow on one side into the coelom through the madreporite, and on the other it may run outside the body by means of the pore-canal. The existence of an opening of the pore-canal is confirmed by means of sections, as well as by observation made externally.

8. The statements made by HEDING ('38) regarding the existence of

the axial organ are confirmed also in the case of the *Molpadia roretzii.* The main part of the axial organ lies on the dorsal wall of the peri-oesophageal sinus, and the two branches arising from the main part are examined both anatomically and histologically.

9. The so-called circular blood-vessel and the radial blood-vessels do not exist in the case of the *Molpadia roretzii*, but just in the place which these vessels occupied originally, there is an organ in the form of canal composed of a loose connective tissue. It is note-worthy that this organ is connected with the axial organ just behind the stone-canal.

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EXPLANATION OF PLATE X

General internal anatomy of the *Molpadia roretzii* (7 cm long, female), the body-wall being opened at the dorsal interradius. ×3.

EXPLANATION OF PLATE XI

Fig. 1. Transverse section of the calcareous ring, showing the arrangement of the tentacular ampullae. ×13.

Fig. 2. Transverse section of the calcareous ring, cut through a portion a little anterior to the position shown in Fig. 1, showing the perforations for the passage of the radial canal and of the radial nerve. aboral view. ×13.

Fig. 3. Longitudinal section of the mouth region. The radial nerve together with the radial canal run through the perforation of the calcareous ring. ×13.

Fig. 4. Transverse section of the anterior part of the body at the radius, showing the longitudinal muscle at its anterior extremity. ×30.

Fig. 5. Transverse section of the middle part of the body-wall, showing the various organs at the radius. ×12.

Fig. 6. Frontal section of the tentacle, showing the membrane which divides the central canal into two compartments. ×30.

EXPLANATION OF PLATE XII

Fig. 7. Transverse section of the tentacular wall, showing the tentacular nerve. ×80.

Fig. 8. Longitudinal section of the pore-canal. ×30.

Fig. 9. Transverse section of the stomach, showing the axial organ. ×30.

Fig. 10. Transverse section of the oesophagus, showing the perioesophageal sinus and the axial organ. ×30.

Fig. 11. Longitudinal section of the body-wall, showing the radial nerve. ×40.

Fig. 12. Longitudinal section of the body-wall, showing the so-called muscle-cylinder. ×30.

ABBREBIATIONS IN PLATES I–III

a	anus	mes	mesentery
ao	axial organ	nr	nerve ring
ap	anal papilla	oes	oesophagus
as	axial sinus	orn	outer band of radial nerve
at	anal tooth	p	pore of stone-canal
asi	anterior small intestine	pbs	peribuccal sinus
bc	body-cavity	pc	pore-canal
bw	body-wall	pf	perforation of calcareous ring
ca	circumnal ampulla	prc	posterior branch of radial canal
cc	circular water-canal	ps	perianal sinus
cch	central chamber	psi	posterior small intestine
cl	cloaca	pos	perioesophageal sinus
cm	circular muscle	pv	polian vesicle
com	commissure of blood-vessel	rb	radial blood-vessel
cr	calcareous ring	rc	radial canal
dm	dorsal mesentery	rm	rete-mirabile
ec	epineural canal	rn	radial nerve
g	genital organ	rt	respiratory-tree
gd	genital duct	sc	stone-canal
gp	genital pore	st	stomach
hc	hyponeural canal	sm	separating membrane
hg	hind-gut	t	tail
irn	inner band of radial nerve	ta	tentacular ampulla
li	large intestine	tc	tentacular canal
lm	longitudinal muscle	te	tentacle
m	mouth	tm	tentacular muscle
mad	madreporite	tn	tentacular nerve
mc	muscle cylinder		
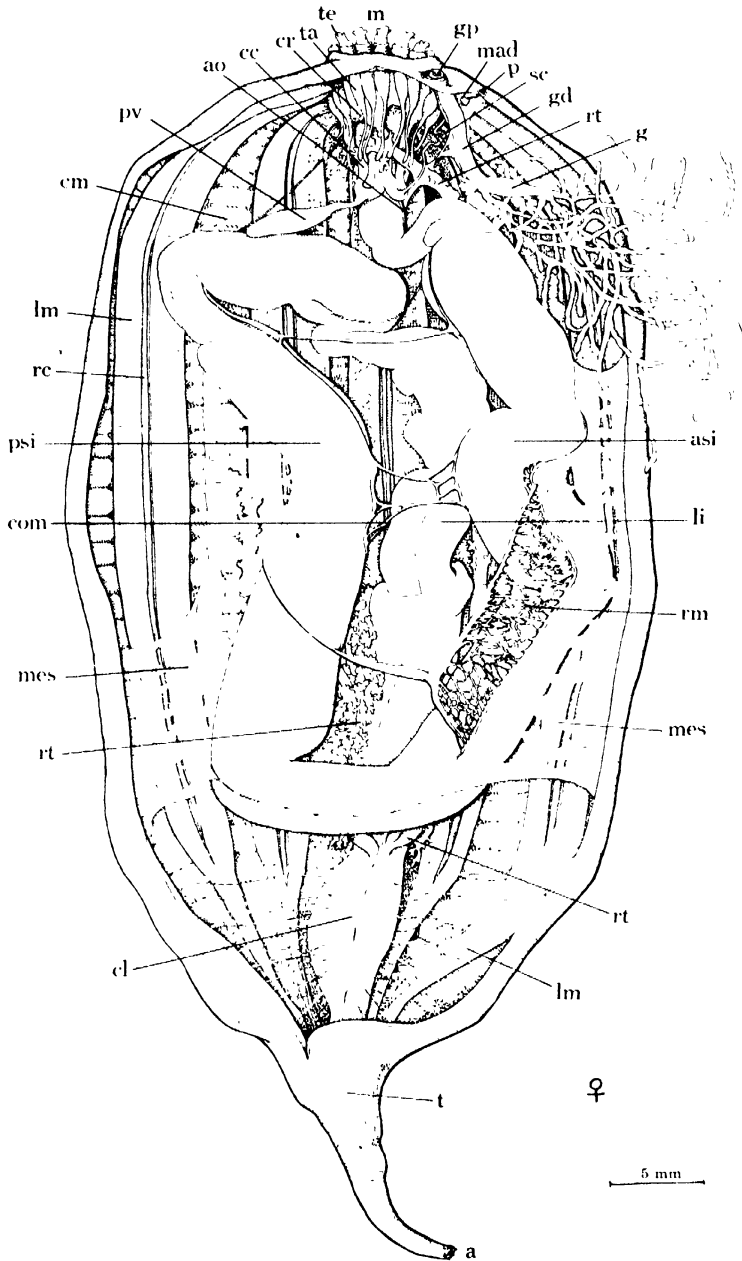
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M. HATANAKA : A Study on *Molpadia roretzii*
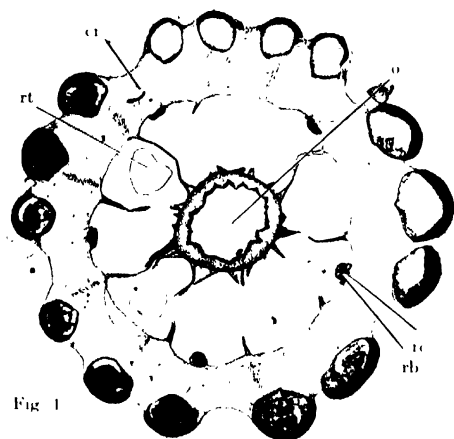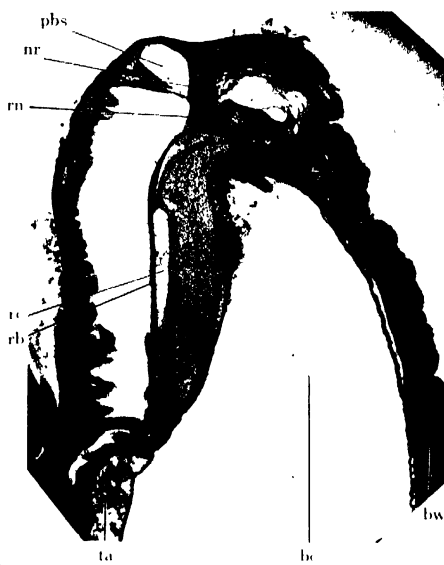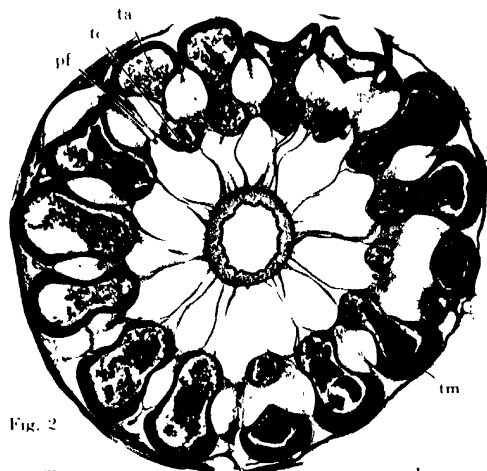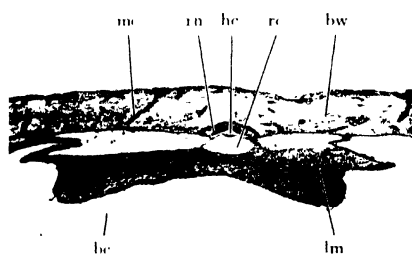
Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

M. Hatanaka photo

M. Hatanaka: A Study on *Molpadia roretzii*

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12

M. HATANAKA photo.

M. HATANAKA : A Study on *Molpadia roretzii*
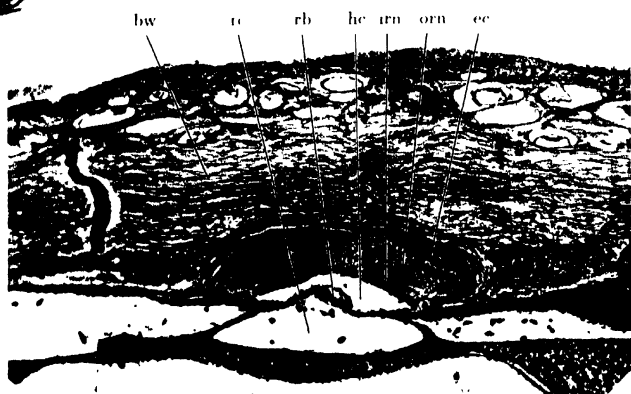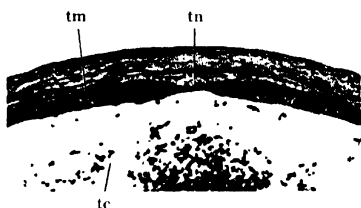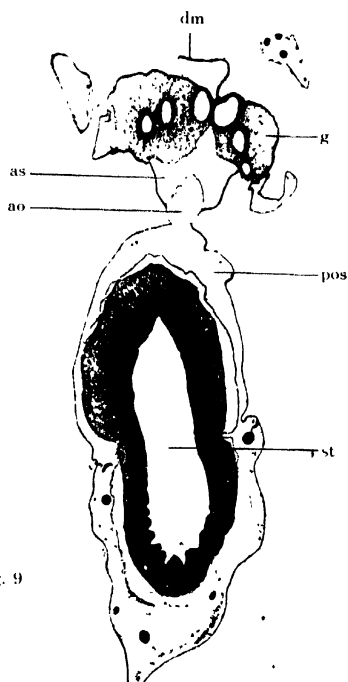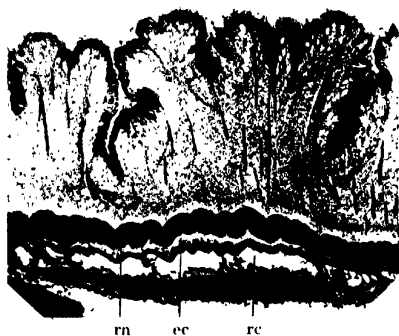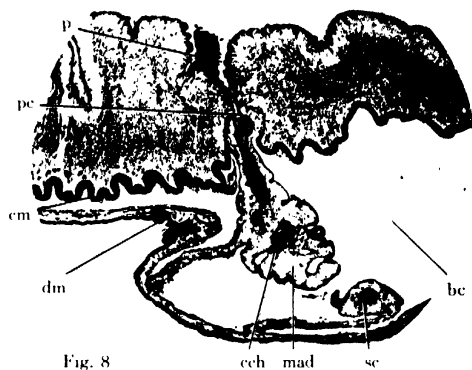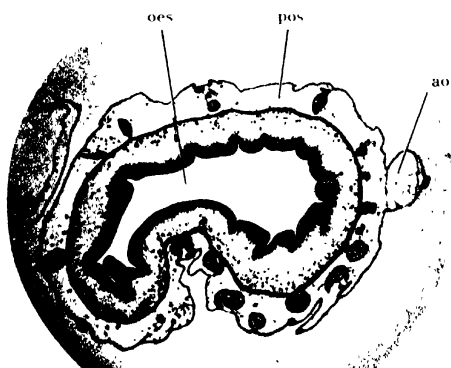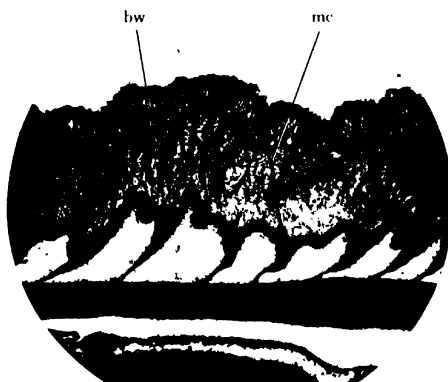
SYMBOLAE ITEOLOGICAE VII

AUCTORE

ARIKA KIMURA

Instituto Biologiae Tôhoku Universitatis Imperialis Sendaiensis

(Opus acceptum d. XXVI m. Maji a. MCMXXXIX)

73) **Balsamiflua**[1] GRIFFITH, Itinerary Notes p. 211 (1848); Notul. Pl. Asiat. IV. p. 382 (1854); Icon. Pl. Asiat. IV. t. 526 (1854).

Syn. *Populus* sect. *Turanga* BUNGE in Mém. Sav. Étr. Acad. Sci. St. Pétersbourg VII. p. 498 (1851) (A. LEMANN Rel. Bot. p. 322).

Populus subgen. *Turanga* DODE in Mém. Soc. Hist. Nat. Autun, XVIII. (1905) (Extr. Monogr. Inéd. Populus p. 13).

Turanga KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 385 (1938).

Genus in sectiones duas dividitur: —

Sect. 1. **Euphraticae** (DODE) KIMURA comb. nov.

Syn. Groupe *Euphratica* DODE in Mém. Soc. Hist. Nat. Autun, XVIII. (1905) (Extr. Monogr. Inéd. Populus p. 14).

Turanga sect. *Euphraticae* KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 386 (1938).

Ad hanc referendae sunt *Balsamiflua euphratica*, *B. diversifolia*, *B. Litwinowiana*, *B. Ariana*, *B. Mauritanica*, *B. Bonnetiana*, *B. ilicifolia*, *B. illicitana*; verisimiliter etiam fossiles *B. mutabilis*, *B. Berggreni*, *B. hyperborea*, *B. Kansascana*, *B. Gaudini*.

Sect. 2. **Pruinosae** (DODE) KIMURA comb. nov.

Syn. Groupe *Pruinosa* DODE in Mém. Soc. Hist. Nat. Autun, XVIII. (1905) (Extr. Monogr. Inéd. Populus p. 14).

Turanga sect. *Pruinosae* KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 386 (1938).

Huc pertinent *Balsamiflua pruinosa*, *B. glaucicomans* et verisimiliter fossilis *B. retusa*.

74) **Balsamiflua euphratica** (OLIVIER) KIMURA comb. nov.

Syn. *Populus euphratica* OLIVIER, Voy. Emp. Othoman. III. p. 449, fig. 45–46 (1807).

Populus euphratica var. *typica* GOMBOCZ in Math. Termész. Közl. XXX. p. 71 (1908) (Monogr. Gen. Populi).

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[1] Hic gratias maximas ago dom. Dr. E. ULBRICH, Musei Botanici Berolinesis Custodi atque Professori, qui mihi benigniter communicavit per litteras nomen *Balsamiflua* GRIFFITHII valide editum et ei *Turangae* (BUNGE) certe praeferendum esse. Sequuntur itaque novae combinationes.

Populus biformis RAFINESQUE, Alsogr. Americ. p. 43 (1838).
Populus euphratensis in Gard. Chronic. 1849, p. 806.
Balsamiflua deltoides GRIFFITH, Icon. Pl. Asiat. IV. t. 526 (1854); Notul. Pl. Asiat. IV.
p. 382 (1854)
Turanga euphratica (OLIVIER) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol.
XIII. p. 386 (1938).

75) **Balsamiflua diversifolia** (SCHRENK) KIMURA comb. nov.

Syn. *Populus diversifolia* SCHRENK in Bull. Acad. Sci. St. Pétersbourg X. p. 253 (1842).
Populus euphratica var. *diversifolia* GOMBOCZ in Math. Termész. Közl. XXX. p. 71
(1908) (Monogr. Gen. Populi).
Populus euphratica B. FEDTSCHENKO, Rast. Turkest. p. 292 (1915) fide KOMAROV.
Turanga diversifolia (SCHRENK) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol.
XIII. p. 387 (1938).

76) **Balsamiflua Litwinowiana** (DODE) KIMURA comb. nov.

Syn. *Populus Litwinowiana* DODE in Mém. Soc. Hist. Nat. Autun, XVIII. (1905) (Extr.
Monogr. Inéd. Populus, p. 17).
Populus euphratica var. *typica* f. *hirta* (LITWINÓW) GOMBOCZ in Math. Termész. Közl.
XXX. p. 71 (1908) (Monogr. Gen. Populi).
Turanga Litwinowiana (DODE) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol.
XIII. p. 387 (1938).

77) **Balsamiflua Ariana** (DODE) KIMURA comb. nov.

Syn. *Populus Ariana* DODE in Mém. Soc. Hist. Nat. Autun, XVIII. (1905) (Extr.
Monogr. Inéd. Populus, p. 16).
Populus euphratica LIPSKY, Ljesn. rast. v. Turkest. p. 17 (1911) fide KOMAROV.
Turanga Ariana (DODE) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p.
387 (1938).

78) **Balsamiflua Mauritanica** (DODE) KIMURA comb. nov.

Syn. *Populus Mauritanica* DODE in Mém. Soc. Hist. Nat. Autun, XVIII. (1905) (Extr.
Monogr. Inéd. Populus, p. 16).
Turanga Mauritanica (DODE) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII.
p. 387 (1938).

79) **Balsamiflua Bonnetiana** (DODE) KIMURA comb. nov.

Syn. *Populus Bonnetiana* DODE in Mém. Soc. Hist. Nat. Autun, XVIII. (1905) (Extr.
Monogr. Inéd. Populus, p. 16).
Populus euphratica var. *typica* f. *Bonnetiana* (DODE) GOMBOCZ in Math. Termész. Közl.
XXX. p. 72 (1908) (Monogr. Gen. Populi).
Turanga Bonnetiana (DODE) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII.
p. 387 (1938).

80) **Balsamiflua ilicifolia** (ENGLER) KIMURA comb. nov.

Syn. *Celtis ilicifolia* ENGLER, Pflanzenwelt Ost-Afrikas p. 160 (1895).
Populus euphratica OLIVIER subsp. *Denhardtiorum* ENGLER in Notizbl. Kön. Bot. Gart.
Mus. Berlin. II. p. 218 (1898).

Populus euphratica OLIVIER var. *Denhardtiorum* GOMBOCZ in Math. Termész. Közl. XXX. p. 72 (1908) (Monogr. Gen. Populi).

Populus Denhardtiorum DODE in HOOKER, Icon. Pl. XXXI. t. 3050 (1916).

Turanga ilicifolia (ENGLER) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 387 (1938).

81) Balsamiflua illicitana (DODE) KIMURA comb. nov.

Syn. *Populus illicitana* DODE in Bull. Soc. Dendrol. France 1908 p. 163, cum fig.

Turanga illicitana (DODE) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 388 (1938).

82) Balsamiflua pruinosa (SCHRENK) KIMURA comb. nov.

Syn. *Populus pruinosa* SCHRENK in Bull. Acad. Sci. St. Pétersbourg III. p. 210 (1845).

Populus euphratica WESMAEL in Bull. Soc. Roy. Belg. XXVI. p. 375 (1887) fide GOMBOCZ.

Turanga pruinosa (SCHRENK) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 388 (1938).

83) × Balsamiflua glaucicomans (DODE) KIMURA comb. nov.
= *B. Ariana* × *B. pruinosa* sec. KOMAROV.

Syn. *Populus glaucicomans* DODE in Mém. Soc. Hist. Nat. Autun, XVIII. (1905) (Extr. Monogr. Inéd. Populus p. 18).

× *Turanga glaucicomans* (DODE) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 388 (1938).

84) Balsamiflua Berggreni (HEER) KIMURA comb. nov. (fossilis).

Syn. *Populus Berggreni* HEER, Fl. Foss. Arct. III. 2, p. 106, t. XXIX. f. 1–5 (1874).

Turanga Berggreni (HEER) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 388 (1938).

85) Balsamiflua hyperborea (HEER) KIMURA comb. nov. (fossilis).

Syn. *Populus hyperborea* HEER, Fl. Foss. Arct. III. 2, p. 106, t. XXIX. f. 6-9, t. XXVII. f. 8 d., t. XXX. f. 2 b (1874).

Turanga hyperborea (HEER) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 388 (1938).

86) Balsamiflua Kansaseana (LESQUEREUX) KIMURA comb. nov. (fossilis).

Syn. *Populus Kansaseana* LESQUEREUX in POWELL, Monogr. U. S. Geol. Survey, XVII. p. 42, t. XVII. f. 1-7 (1892) (The Flora of the Dakota Group).

Turanga Kansaseana (LESQUEREUX) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 388 (1938).

87) Balsamiflua Gaudini (FISCHER-OOSTER) KIMURA comb. nov. (fossilis).

Syn. *Populus Gaudini* FISCHER-OOSTER ex HEER, Fl. Tert. Helv. II. p. 24, t. LXIV. (1856).

Turanga Gaudini (FISCHER-OOSTER) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 388 (1938).

88) **Balsamiflua mutabilis** (HEER) KIMURA comb. nov. (fossilis).

Syn. *Populus mutabilis* HEER, Fl. Tert. Helv. II. p. 19 (1856).

Populus ovalis A. BRAUN in BUCKLAND, Geolog. & Mineralog.

Populus ovalifolia A. BRAUN in BRONNS Jahrb. p. 169 (1845).

Laurus dermatophyllon O. WEBER in Palaeontogr. II. p. 182, t. XIX. f. 13 (1852).

Populus Aeoli A. BRAUN in BRÜCKMANN, Fl. Oening. Foss. p. 230 (1850).

Ficus pannonica ETTINGSHAUSEN, Foss. Fl. v. Tokay p. 26, t. I. f. 9 (1854).

Quercus ovalis GOEPPERT, Foss. Fl. v. Schossnitz t. VI. f. 6 (1855).

Turanga mutabilis (HEER) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 388 (1938).

89) **Balsamiflua retusa** (HEER) KIMURA comb. nov. (fossilis).

Syn. *Populus retusa* HEER, Fl. Foss. Arct. IV. p. 69, t. XIV. f. 6-7 (1876).

Turanga retusa (HEER) KIMURA in Sci. Rep. Tôhoku Imp. Univ. 4 ser. Biol. XIII. p. 389 (1938).

FURTHER STUDIES OF THE SYSTEMATIC RELATIVE GROWTH OF THE SHELLS OF THE MOLLUSCANS, *OBBA*, *COCHLOSTYLA* AND *OPISTHOPORUS*

By

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(With 1 figure)

(Received April 26, 1939)

The systematic relative growth of some of the genera belonging to Cypraeidae has recently been discussed in a paper by the present writer[1]. In that paper he described both the interspecific and the inter-genus relation of size, pointing out that the size-distribution of individuals belonging to one species can be expressed by the same equation as that of the allometry, which describes the relative growth, the constants b and α in this equation being conditioned by the formula,

$$b = B e^{-r\alpha} + C,$$

B, r and C being the constants, and e the base of the natural logarithms, among the species within a definite group containing allied species. Also that in the mutual relation between the mean dimensions of every species belonging to this group, the same formula as the allometric equation, $y = bx^\alpha$, can be applied with small deviations, and that, apparently the size-relation between the allied species of the molluscan shells is probably limited to the two equations,

$$y = bx^\alpha \qquad \text{and} \qquad b = B e^{-r\alpha} + C.$$

In this paper, some new information on the systematic relative growth of the genus *Obba* and others, has been added. The subspecies have been dealt with, being applied to the equation, $y = bx^\alpha$, and the genus, containing the species with these many subspecies, has been further conditioned by the b-α relation.

Before proceeding further, the writer wishes to express many thanks to Prof. E. NOMURA for his valuable help, and for his kindness in reading the manuscript of this paper.

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[1] HAMAI, I. 1938. Systematic Relative Growth in *Cypraea-Erronea-Pustularia-Talparia* Group. Sci. Rept. Tôhoku Imp. Univ., Biol., Vol. 13, pp. 15–24.

THE SIZE-RELATION BETWEEN SUBSPECIES

The sizes of the subspecies are shown in Table 1[2]. The greater diameter and the lesser diameter or the height of every subspecies belonging to one species are in a definite relation within the species. This relation can be expressed by the formula, $y=bx^{a}$, which describes the allometry of one species or subspecies, with small probable errors (Table 2). In this formula, y is the lesser diameter or the height, x the greater diameter, and b and α are the constants. These regular relations between the subspecies within a species probably prove that the hereditary factors of a subspecies limiting the form and the relative growth, are not only similar to those of an allied subspecies, but also that, between those of each subspecies, there exists a regular quantitative tendency similar to the arrangement on the curve of the formula mentioned above, without random differences. In other words, the regular relation of the shell-height to the greater diameter shows a regularity of variation in the direction of the spiral, and the regular relation of the lesser diameter of the shell to the greater explains the existence of the regular variability of the angle between the tangent of the spiral curve of the shell and the radius vector of the curve, from one subspecies to another. The mathematical treatment of the spiral curve has been undertaken by THOMPSON[3] and PETERSEN[4] by means of logarithmic spirals as the expression of the shell-curve. HUXLEY[5] has further examined it from the standpoint of the existence of relative growth, or of growth-ratio and growth-gradient. The regular variabilities are, then, confirmed by the fact that there are small differences in the growth-gradient along the margin of the shell-aperture varying slightly from one species to another, and that a simple, quantitative regularity of these differences exists between the subspecies within a species.

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[2] These data were taken from BARTSCH's following descriptions:—

BARTSCH, PAUL. 1932. The Philippine Land Mollusks of the Genus *Opisthoporus*. Contributions to the Biology of the Philippine Archipelago and Adjacent Regions. Smithonian Inst., U. S. Nat. Mus. Bull. 100, Vol. 6, Part 6.

Ditto. 1932. The Philippine Land Mollusks *Cochlostyla rufogaster* and *Obba marmorata* and their Races. ibid., Vol. 6, Part 7.

Ditto. 1933. The Land Shells of the Genus *Obba* from Mindoro Province, Philippine Islands. ibid., Vol. 6, Part 8.

[3] THOMPSON, D'ARCY W. 1917, Growth and Form. Cambridge.

[4] PETERSEN, CHR. 1921. Das Quotientengesetz: eine biologische Untersuchung. Kopenhagen.

[5] HUXLEY, J. S. 1932. Problems of Relative Growth. London.

TABLE 1

Subspecies	No. of specimens	Greater diameter (mm.)	Lesser diameter (mm.)	Height (mm.)
Opisthoporus quadrasi turturinganus BARTSCH	2	14.50	10.80	6.70
O. q. quadrasi CROSSE	1	14.70	11.30	7.80
O. q. busuangensis BARTSCH	1	16.10	12.00	8.00
O. q. palawanensis BARTSCH	5	16.80	12.52	7.64
Cochlostyla rufogaster monozona (PFEIFFER)	4	36.63		49.10
C. r. antipolana BARTSCH	3	42.03		55.47
C. r. juani BARTSCH	15	44.59		61.79
C. r. manilana BARTSCH	2	49.10		69.75
C. r. rufogaster (LESSON)	2	49.44		77.91
C. r. benguetana BARTSCH	1	50.70		76.20
C. r. banahaona BARTSCH	1	52.00		73.00
C. r. montalbana BARTSCH	4	52.83		71.78
G. r. toppingi BARTSCH	3	57.10		89.00
Obba listeri recurvata (MÖLLENDORFF)	13	23.21	18.75	10.25
O. l. sibolonensis BARTSCH	6	23.88	20.10	10.48
O. l. halcona BARTSCH	1	27.40	22.80	9.90
O. l. minor (MÖLLENDORFF)	1	28.00	23.20	10.80
O. l. subplanulata (MÖLLENDORFF)	1	28.10	23.10	11.50
O. l. campoensis BARTSCH	5	30.52	25.18	13.74
O. l. mayabigana BARTSCH	14	31.79	25.79	14.04
O. l. smithi BARTSCH	1	35.30	28.20	12.50
Obba subhorizontalis radchiffei BARTSCH	1	27.80	22.60	12.00
Obba sarcochroa ilogana BARTSCH	9	29.21	23.29	16.59
Obba planulata cagurayana BARTSCH	1	26.90	21.30	13.60
O. p. planulata BARTSCH	14	27.06	21.47	13.50
O. p. salcedol BARTSCH	1	27.30	23.00	11.80
O. p. mansalayana BARTSCH	25	28.32	22.19	13.37
O. p. medioensis BARTSCH	25	28.68	22.90	13.78
O. p. bongabona BARTSCH	3	30.63	24.53	13.03
O. p. lubangensis BARTSCH	8	30.79	24.13	14.66
O. p. varaderoana BARTSCH	9	31.78	25.69	15.18
O. p. verdensis BARTSCH	1	32.20	24.90	12.30
Obba gallinula barthelowi BARTSCH	1	25.90	21.00	11.00
Obba marmorata benguetana BARTSCH	4	16.68	11.68	13.80
O. m. rizalana BARTSCH	14	28.31	22.09	13.85
O. m. ecijava BARTSCH	5	30.94	24.06	17.92
O. m. bolinaoana BARTSCH	1	31.90	24.30	17.50
O. m. marmorata (MÖLLENDORFF)	3	35.60	27.70	19.30
Obba mesai richi BARTSCH	3	29.13	22.40	14.10
O. mesai johnsoni BARTSCH	1	29.20	22.50	13.00
O. mesai mesai BARTSCH	26	29.75	22.17	14.04
O. mesai sablayana BARTSCH	11	31.79	25.05	13.35

TABLE 2

Species	$\alpha \pm$ P. E.	$\log b \pm$ P. E.
	Lesser/greater diameter relation	
Obba listeri	0.98350 ± 0.01064	$\bar{1}.93594 \pm 0.01531$
Obba planulata	1.04816 ± 0.02267	$\bar{1}.82905 \pm 0.03311$
Obba marmorata	1.17020 ± 0.01028	$\bar{1}.64191 \pm 0.01479$
Obba mesai	1.66274 ± 0.04666	$\bar{2}.89904 \pm 0.06907$
Opisthoporus quadrasi	0.93713 ± 0.10965	$\bar{1}.94935 \pm 0.13190$
	Height/greater diameter relation	
Cochlostyla rufogaster	1.26207 ± 0.04141	$\bar{1}.71008 \pm 0.06893$

The applicability of the equation, the same as in the case of the allometric one, can probably be extended from a species to a genus or to a group, with the knowledge of the fact that allied species are gathered into a genus or into a group. The regular variability of species within a group has been found in *Cypraea-Erronea-Pustularia-Talparia* group[1]. In the present enquiry this has also been proved in the genus *Obba*. That is, the genus *Obba* containing four species or 29 subspecies is defined by the following equation,

$$y = bx^{\alpha}$$

in which $\alpha = 1.04397 \pm 0.01341$ and $\log b = \bar{1}.83264 \pm 0.01954$. In this equation y represents the lesser diameter and x the greater. This fact means that there exists a systematic variability of size between species, or between subspecies which are held to belong to the genus.

As the height/greater diameter relation of *Obba* shows great variation, its analysis has not been attempted, but this relation seems also to have a trend of variability, which is not irremovable but which is regularly directional.

As it is considered that this systematic, variability between subspecies within a species and within a genus shows the trend of variability of subspecies or of species, and as its existence was discovered in the course of a differentiation of species, and is considered to originate in the progressive nature of the relative growth of each subspecies or species, the constant α can probably be defined as the "equilibrium constant of the systematic relative growth," and b the "local index" which provides a location of the equation[6].

[1] HAMAI, I. 1938. loc. cit.

[6] HAMAI, I. 1939. On the Growth of the Embryonic Shell of the Japanese River Snail, *Viviparus japonicus*. Sci. Rept. Tôhoku Imp. Univ., Biol., Vol. 14, pp. 1-10.

INTRA-GENUS RELATIONSHIP

In the group containing *Erronea* and *Pustularia*[1], the constants b and α of each species have been found to be arranged on the curve with the expression,

$$b = B\,e^{-r\alpha} + C.$$

This relation is, of course, an empirical approximation, as has been already mentioned in HAMAI's recent papers[1][6]. In the genus *Obba*, a form of the equation simpler than the upper is applied, i. e.

$$b = B\,e^{-r\alpha}, \quad C = 0,$$

or
$$\log b = \log B - 0.4343\,r\alpha$$

$$= q - p\alpha$$

where $p = 0.4343\,r$ and $q = \log B$. That is,

$$p = 1.51905 \pm 0.00070$$

and
$$q = 1.42361 \pm 0.00085$$

have been observed in the genus *Obba* (Fig. 1).

The existence of this formula means that the equations of every species with the form of $y = bx^\alpha$ inter-sect on the definite point $(\log^{-1}p,\ \log^{-1}q)$. It has actually been observed that the intersecting point of each two equations does not strictly co-incide, but that their curves roughly concentrate near this point.

Thus, this relation is empirically useful in order to condition the variability of species within a genus. The following conclusions are, then, derived showing that the trend of variability of subspecies within the species is limited by the definite relation as expressed by the formula, $\log b = q - p\alpha$, within the genus which contains these species.
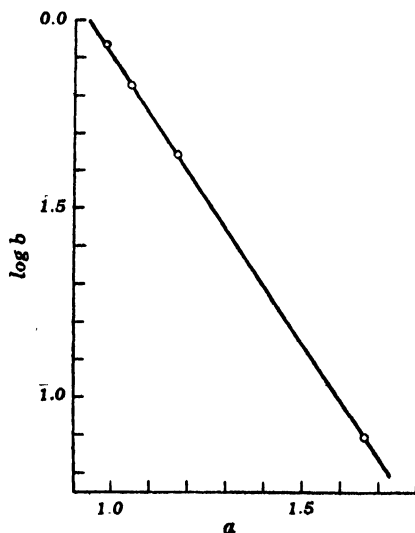
Fig. 1. *b*-α relation of the genus, *Obba.*

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[1] HAMAI, I. 1938. loc. cit.

[6] HAMAI, I. 1939. loc. cit.

SUMMARY

From the lesser/greater diameter and the height/greater diameter relations of *Obba*, *Opisthoporus*, and *Cochlostyla*, the following conclusions are arrived at : —

1) The trend of variability in size between subspecies is expressed by the equation $y=bx^\alpha$, where y and x are mutually comparable dimensions, α is the equilibrium constant of systematic relative growth and variation, and b the local index.

2) In a genus the trend of variability within a species is conditioned by the formula, $\log b = q - p\alpha$, where p and q are the constants, the antilogarithms of which are the co-ordinates of the definite point representing the definite size of the shell.

3) These relations depend upon the systematic variability of the growth-gradients in the margin of the shell-aperture, which every subspecies shows, and this variability has a directional regularity within a genus.

STUDIES OF THE CIRRIPEDIAN FAUNA OF JAPAN
V. CIRRIPEDS OF THE NORTHERN PART OF HONSYÛ

By

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(Received April 26, 1939)

INTRODUCTION

This is the fifth of a series of papers on the cirripedian fauna of Japan and relates to the cirripeds occurring in the Tôhoku and Hokuriku Districts, northern Honsyû. Our knowledge of the cirripedian fauna of these districts was previously very limited. Prior to my previous short paper (Hiro, 1932) dealing with the material from Mutsu Bay, Krüger (1911) and Pilsbry (1911, 1916) had recorded only a few common species from the neighbourhood of Matusima; since then the surveying ship, "Sôyô-maru" of the Imperial Fisheries Experimental Station has from the deep waters near these localities obtained a few other species which have been reported upon by me (Hiro, 1933).

On the occasion of my visit to the Tôhoku and Hokuriku Districts in the autumn of 1935, I collected cirripeds in several places. Besides these, all the undetermined material deposited in various museums and institutions situated in these districts was with the greatest courtesy placed at my disposal.

All the material dealt with in this paper is from the following six sources: The Saitô Hô-on Kai Museum at Sendai (Dr. S. Hatai, Mr. Sh. Ohfuchi) possesses about 29 samples, all collected in various spots of the Tôhoku District; as well as a few fossil specimens which I have not examined. The museum of the Biological Institute of the Tôhoku Imperial University at Sendai (Prof. S. Hôzawa, Mr. H. Satô) has a very few samples, mainly taken from the Onagawa and Mutsu Bays. In the Ocean-chemical Institute of the Tôhoku Imperial University at Onagawa (Dr. T. Imai), there are about 51 samples collected during the survey of Onagawa Bay and its vicinity. The Marine Biological Station of the Tôhoku Imperial University at Asamusi (Prof. S. Hôzawa) has about 16 samples mainly from Mutsu Bay, most of them duplicates of those

which I had already examined. The little collection stored in the museum
of the Biological Institute of the Toyama High School at Toyama (Mr.
K. KIKUCHI), mainly from the Toyama Bay and its vicinity, was also
examined. Lastly, my own private collection made during my visit to
the Tôhoku and Hokuriku Districts is also dealt with in this paper.

To all the gentlemen in charge of these Museums and Institutions I
wish to express my grateful thanks for so kindly having placed their
material at my disposal.

These collections contain in all 30 different forms, if subspecies and
varieties are also included. All of them were already known as existing
in Japanese waters, and have been morphologically thoroughly studied
in the past. Although no new or rare species is represented in these
collections, this report will be of some interest from the zoogeographical
view-point, and will aford some aid to future students of the zoogeography
of the northern regions concerned.

The abbreviations of the sources of the material are as follows:

S.H.M. — Saitô Hô-on Kai Museum, Sendai.

T.I.U. — Biological Institute, Tôhoku Imperial University, Sendai.

O.C.I. — Ocean-chemical Institute, Tôhoku Imper. Univ., Onagawa.

M.B.S. — Marine Biological Station, Tôhoku Imper. Univ., Asamushi.

T.H.S. — Biological Institute, Toyama High School, Toyama.

M.P.C. — My private collection from northern Honsyû.

<div align="center">SYNOPSIS OF THE SPECIES</div>

<div align="center">LEPADOMORPHA</div>

<div align="center">Family Scalpellidae PILSBRY</div>

<div align="center">1. Mitella mitella (LINNÉ)</div>

Pollicipes mitella: DARWIN, 1851, p. 316; NILSSON-CANTELL, 1921, p. 163.
Mitella mitella: PILSBRY, 1907, p. 6; KRÜGER, 1911, p. 8; BROCH, 1922, p 258; HIRO,
        1937 a, p. 23.

Localites. Pacific coast: Onahama, Hukusima-ken. VI '31. H. KA-
DOTA. (S.H.M.-Reg. No. 7125); Matusima Bay Miyagi-ken. PILSBRY (1911,
p. 61); Watanoha Bay, Miyagi-ken. 15/VIII '31. N. TAKEDA. (S.H.M.);
Southern coast of Azi-sima, southwest of Ozika Peninsula, Miyagi-ken.
8/VI '32. Sh. OHFUCHI. (S.H.M.-Reg. No. 16481); Hûkiura, Ozika
Peninsula. 30/VIII '21. (T.I.U.); Onagawa Bay, Miyagi-ken. 31/VII '33.
K. IWABUCHI. (S.H.M.-Reg. No. 17789); Onagawa Bay. 4/VIII '32. SH.
OHFUCHI. (S.H.M.); Kasagai-zima, Onagawa Bay. 16/VII '35. (O.C.I.-Sp.

No. 497); Sannô-zima, Onagawa Bay. 30/VII '35. (O.C.I.-Sp. No. 950); Iigohama, Onagawa Bay. 19/VIII '35. (O.C.I.-Sp. No. 1080); Izu-sima, Onagawa Bay. 27/VIII '35. (O.C.I.-Sp. No. 1138); Izu-sima, Onagawa Bay. 20/VIII '31. (T.I.U.); Ôsima, Kesen-numa, Miyagi-ken. 8/VIII '32. H. YOSIZAWA. (S.H.M.-Reg. No. 18239); Simoodai, Simokita Peninsula. 18/VIII '32. Y. MURAKAMI. (S.H.M.-Reg. No. 1310).

Mutsu Bay: Ôsima. 14/VII '31. T. TAMURA & N. ABE. (S.H.M.); Asamushi, Aomori-ken. VIII '25. K. SASAKI. (T.I.U.); Hutago-zima (=Futago-jima). HIRO (1932, p. 546); Hutago-zima, near Asamushi. 24/VII '32. E. SAWANO. (S.H.M.-Reg. No. 1269).

Japan Sea coast: Tappi-saki, northernmost promontory of Simokita Peninsula. 22/VII '29. S. HÔZAWA. (M.B.S.-Sp. No. 2495); Iwadate, Yamamoto-gun, Akita-ken. 25/VIII '31. S. ONO. (S.H.M.); Kamo, Yama-gata-ken. VIII '32. K. NODA. (S.H.M.-Reg. No. 20190); Nezugaseki, Yamagata-ken. 20/X '35. F. HIRO. (M.P.C.); Abuga-sima, Toyama Bay. K. KIKUCHI. (T.H.S.); Tôzinbô, Hukui-ken. K. KIKUCHI. (T.H.S.).

Occurrence in Japan. Widely distributed in the littoral region of Honsyû, Sikoku, Kyûsyû, Tyôsen, Ryûkyû Is. and northeastern part of Taiwan.

Further distribution. Indo-Pacific.

2. Calantica scorpio (AURIVILLIUS)

Scalpellum scorpio; AURIVILLIUS, 1894, p. 46.
Scalpellum sexcornutum : PILSBRY, 1897, p. 723.
Smilium sexcornutum : KRÜGER, 1911, p. 15.
Calantica scorpio : BROCH, 1931, p. 6; HIRO, 1933, p. 13; HIRO, 1937 a, p. 29.

Locality. Toyama Bay. Depth 50-70 m, Bottom-sand and mud. 19/VII '35. K. KIKUCHI. (T.H.S.).

Occurrence in Japan. Several places in the deep basin on the Pacific side of middle and southern Japan, down to about 150 m. It is also known from off Tango, the Japan Sea (WELTNER, 1922).

Further distribution. E. & S. China Sea, Siam (see HIRO, 1937 b).

3. Scalpellum stearnsi PILSBRY

Scalpellum stearns : PILSBRY, 1890, p. 441; PILSBRY, 1907, p. 14; KRÜGER, 1911, p. 18; NILSSON-CANTELL, 1921, p. 175; HIRO, 1937 a, p. 35.

Locality. Miyako Bay, Iwate-ken. 30/VIII '35. Miyako Fishery School. (T.I.U.).

Occurrence in Japan. Deep waters on the Pacific and East China Sea coasts.

Further distribution. Malay Archipelago.

Family Lepadidae (Darwin) Nilsson-Cantell
4. Lepas anatifera Linné

Lepas anatifera: Darwin, 1851, p. 73; Krüger, 1911, p. 23; Broch, 1924. p. 46; Hiro, 1937 a. p. 56; Hiro, 1937 b, p. 396.

Localities. Syôbutahama, near Matusima Bay, Miyagi-ken. On a floating timber. (S.H.M.); off Kinkasan, Miyagi-ken. 28/VI '36. (O.C.I.-Sp. No. B-111); off Onagawa Bay. (O.C.I.-Sp. No. B-115); Miyako Bay, Iwate-ken. On a piece of floating straw. 20/V '35. S. Tominaga. (T.I.U.); Miyako Bay. Krüger (1911, p. 25); off Asamushi, Aomori-ken. T. Moriyama. (M.B.S.; Hiro, 1932, p. 546); off Niigata, Japan Sea side. 16/IX '32. K. Ikeda. (M.P.C.); Toyama Bay. K. Kikuchi. (T.H.S.).

Distribution. Pelagic in all seas.

5. Lepas anserifera Linné

Lepas anserifera: Darwin, 1851, p. 81; Hiro, 1937 a, p. 57; Hiro, 1937 b, p. 399.

Localities. Nezugaseki, Yamagata-ken. 20/X '35. F. Hiro (M.P.C.); Husiki, Toyama Bay. On bamboo. K. Kikuchi. (T.H.S.).

Distribution. Pelagic chiefly in tropical and temperate seas.

6. Lepas pectinata Spengler

Lepas pectinata: Darwin, 1851, p. 85; Hiro, 1937 a, p. 59.

Localities. Koyatori, Onagawa Bay. 18 m in depth. 19/VII '35. (O.C.I.-Sp. No. 784); Terama, Onagawa Bay. On a branch of pine-tree. 17/I '38. (O.C.I.-Sp. no. 1616); 50 miles E. off Onagawa Bay. Associated with *Lepas fascicularis.* 8/VII '36. (O.C.I.-Sp. No. 1645).

Distribution. Pelagic commonly in tropical and temperate seas.

7. Lepas fascicularis Ellis & Solander

Lepas fascicularis: Darwin, 1851, p. 92; Broch, 1924, p. 51; Hiro, 1937 a, p. 60; Hiro, 1937 b, p. 400.

Locality. 50 miles E. off Onagawa Bay. A specimen associated with *Lepas pectinata.* 8/VII '36. (O.C.I.-Sp. No. 1645). This is the third record of occurrence of this species from the Japanese waters.

Distribution. Pelagic chiefly in tropical and temperate seas.

8. Conchoderma auritum (LINNÉ)

Conchoderma aurita : DARWIN, 1851, p. 141.
Conchoderma auritum : NILSSON-CANTELL, 1921, p. 240; BROCH, 1924, p. 55; CORNWALL, 1927, p. 513; HIRO, 1937 a, p. 61.

Localities. Ayukawa, Miyagi-ken. On the whale *Megaptera nodosa.* 15/X '35. F. HIRO. (M.P.C.); Samé, Aomori-ken. On *Megaptera nodosa.* Sh. CHIBA, (Same Fisheries Experimental Station). 7/VI '35. (T.I.U.).
Distribution. Pelagic in all seas, usually on *Coronula diadema* attached to whales.

9. Conchoderma virgatum (SPENGLER)

Conchoderma virgata : DARWIN, 1851, p. 146.
Conchoderma virgatum : BROCH, 1924, p. 58; HIRO, 1937 a, p. 62.

Localities. Off Kinkasan, Miyagi-ken. On *Penella.* (O.C.I.-Sp. No. B-110); off Siriya-zaki, Aomori-ken. VII '32. H. SATÔ. (T.I.U.).
Distribution. Pelagic in all seas, usually on *Penella* parasitic on the skin of fishes.

10. Conchoderma virgatum hunteri (OWEN)

Conchoderma Hunteri : DARWIN, 1851, p. 153.
Conchoderma virgatum f. *Hunteri :* KRÜGER, 1911, p. 26.
Conchoderma virgatum Hunteri : HIRO, 1937 a, p. 63; HIRO, 1937 b, p. 402.

Locality. Toyama Bay. Growing on the carapace of the crab *Neptunus trituberculatus.* K. KIKUCHI. (T.H.S.).
Occurrence in Japan. Sagami Bay (KRÜGER), Seto, Tosa Bay (HIRO).
Further distribution. Indo-Pacific, usually attached to the skin of sea-snakes or crabs.

Family Heteralepadidae NILSSON-CANTELL

11. Heteralepas (Paralepas) minuta (PHILIPPI)

Alepas minuta : DARWIN, 1851, p. 160.
Heteralepas (Paralepas) minuta : HIRO, 1933, p. 51.

Localities. See below.
Occurrence in Japan. Japan Sea coast of the Tôhoku and Hokuriku Districts (110–207 m in depth). Attached to the spine of cidarids (HIRO, 1933).
Further distribution. Northwest coast of Africa and the Mediterranean. There is a doubtful record from Java (WELTNER, 1897).

Family Trilasmatidae NILSSON-CANTELL

12. Octolasmis weberi (HOEK)

Dichelaspis Weberi: HOEK, 1907, p. 26.
Octolasmis Weberi: HIRO, 1933, p. 58; HIRO, 1937 a, p. 92.

Locality. N. E. off Sado Is., Japan Sea. Depth 210 m.

Occurrence in Japan. The same as the above locality. Its subspecies *pennatulae* HIRO (1937) is known from the Pacific coast of middle Japan.

Further distribution. Malay Archipelago, South Africa. Depth 137–560 m.

13. Octolasmis lowei (DARWIN)

Dichelaspis Lowei: DARWIN, 1851, p. 128.
Paradolepas neptuni: MAC DONALD, 1869, p. 442.
Dichelaspis Vaillanti: GRUVEL, 1905, p. 128.
Octolasmis lowei: NILSSON-CANTELL, 1927 (with discussion on synonymy); HIRO, 1937 a, p. 94.

Localities. Moura-zima, Mutsu Bay. On the gills of *Neptunus trituberculatus.* VIII '27. T. YAMANOUTI. (M.B.S.-Sp. No. 2305); Asamushi, Mutsu Bay. On the maxillipeds of *Neptunus trituberculatus.* (M.B.S.).; Nonai, near Asamushi. On the gills of *Neptunus trituberculatus.* 6/VII '27. S. TAKATSUKI. (M.B.S.-Sp. No. 1621).

Occurrence in Japan. Mutsu Bay (see above).

Further distribution. Malay Archipelago, Australia, Indian Ocean, Atlantic Ocean. Attached to gills or mouth-feet of crabs and lobsters.

Remarks. Both the specimens of this species taken from Mutsu Bay have been fully described by me in a previous paper under *Octolasmis aymonini* living on the gills of *Macrocheira kaempferi* with a discussion on the differences between them (HIRO, 1937 b, pp. 419–426). They have apparently a close resemblance in their external characteristics, but not as regards their internal characteristics, especially in the shape of the mandible and maxilla I. By the shape or the degree of decalcification of the capitular plates, it may be best to regard these specimens from Mutsu Bay as *Octolasmis lowei* forma *neptuni* (MAC DONALD). The differences among *O. lowei* (DARWIN), *Paradolepas neptuni* MAC DONALD and *Dichelaspis Vaillanti* GRUVEL are not constant, and are not so important as to specifically or subspecifically separate one from the other, as is pointed out by NILSSON-CANTELL (1927).

BALANOMORPHA
Family Chthamalidae DARWIN
14. Chthamalus challengeri HOEK

Chthamalus challengeri: HOEK, 1883, p. 165; PILSBRY, 1916, p. 307; NILSSON-CANTELL, 1921, p. 279; HIRO, 1933, p. 546.
Chthamalus challengeri nipponensis: PILSBRY, 1916, p. 309.

Localities. Pacific coast: Kinkasan, S.E. of Ozika Peninsula. 16/X '35. F. HIRO. (M.P.C); Amizi, S.W. of Ozika Peninsula. 8/VI '32. Sh. OHFUCHI. (S.H.M.-Reg. No. 16481); Ayukawa and PILSBRY (1916, p. 308); Sannô-zima, Onagawa Bay. 30/VII '35. (O.C.I.-Sp. Nos. 950, 961); Izusima, Onagawa Bay. 27/VIII '35. (O.C.I.-Sp. No. 1138); Nakasima, Onagawa Bay. 1/VII '35. K. KIMURA. (O.C.I.-Sp. No. XIII, ii, C-8).

Mutsu Bay: Hutago-zima (=Futago-jima). S. HÔZAWA. (M.B.S.; HIRO, 1933, p. 548); Hutago-zima. 24/VII '32. E. SAWANO. (S.H.M -Reg. Non. 1269); Ôsima. 14/VII '32. N. ABE & T. TAMURA. (S.H.M.); Asamushi. 17/X '35. F. HIRO. (M.P.C.).

Japan Sea coast: Tôzinbô, Hukui-ken. On *Tetraclita squamosa japonica*. K. KIKUCHI. (T.H.S.).

Occurrence in Japan. Widely distributed in the mainland of Japan. In Hokkaidô it is known from Hakodate only, and in Taiwan it is not found.

Further distribution. Malay Archipelago, Indian Ocean (acc. to NILSSON-CANTELL), Red Sea (acc. to BROCH).

15. Octomeris sulcata NILSSON-CANTELL

Octomeris sulcata: NILSSON-CANTELL, 1932, p. 8.

Locality. Nezugaseki, Yamagata-ken. On the shell of *Haliotis gigantea*. 20/X '35. F. HIRO. (M.P.C.).

Occurrence in Japan. Honsyû: Kôbe, Seto. Kyûsyû: Tomioka. Ryûkyû Is.: Yaéyama Is. Taiwan: Takao.

Remarks. This interesting species, only known in a few localities of Japan as mentioned above, is clearly characterized by the concrescense of the rostrum and rostrolatera and the presence of a caudal appendage. In the southern localities, such as Takao and Tomioka, this species lives abundantly on costal rocks, while in the more northerly located Seto and Nezugaseki it seems to be limited to the sublittoral region. Full description and discussion of its morphology will be given in another paper dealing with the cirripeds of Taiwan.

Family **Balanidae** GRAY

Subfamily **Balaninae** DARWIN

16. Balanus tintinnabulum volcano PILSBRY

Balanus tintinnabulum volcano: PILSBRY, 1916, p. 60; NILSSON-CANTELL, 1932, p. 19;
HIRO, 1937 b, p. 430.

Locality. Tôzinbô, Hukui-ken. VIII '30. F. HIRO. (M.P.C.).

Occurrence in Japan. Pacific coast of southern Japan as far north
as the Sagami Bay.

Further distribution. Recently NILSSON-CANTELL (1938) recorded this
subspecies from the Krusadai Island in the Gulf of Manaar, based on
the opercular valves only. If his identification is correct, this is the first
record of its occurrence from the waters outside of Japan.

17. Balanus tintinnabulum rosa PILSBRY

Balanus tintinnabulum rosa: PILSBRY, 1916, p. 61; NILSSON-CANTELL, 1932, p. 16;
HIRO, 1932, p. 549; HIRO, 1937 b, p. 431.

Localities. Pacific coast: Ayukawa, Ozika Peninsula. 15/X '35. F.
HIRO. (M.P.C); Sannô-zima, Onagawa Bay. 30/VII '35. (O.C.I.-Sp. Nos.
954, 962 a, 963); Izu-sima, Onagawa Bay. Depth 34 m. Collected by
dredging. 23/VII '35. (O.C.I.-Sp. No. 844); Konorihama, Onagawa Bay.
On buoys. I '35. MATSUZAKA. (O.C.I.-Sp. No. XIII, A, ii, C-2).

Mutu Bay: Hutago-zima. S. HÔZAWA. (M.B.S.; HIRO, 1932, p. 550).

Japan Sea coast: Tappi-saki, Tugaru Strait. 6/V '32. N. ABE. (S.H.M.-
Reg. No. 1075); Hunakawa, Akita-ken. 19/X '35. F. HIRO. (M.P.C.);
Nezugaseki, Yamagata-ken. 20/X '35. F. HIRO. (M.P.C.); off Kanazawa,
Isikawa-ken. 22/X '35. F. HIRO. (M.P.C.); Tôzinbô, Hukui-ken. K. KIKUCHI.
(T.H.S.).

Occurrence in Japan. Hitherto known only from all the seas around
Japan, from Taiwan to Mutsu Bay.

18. Balanus amphitrite communis DARWIN

Balanus amphitrite communis: DARWIN, 1854, p. 240; NILSSON-CANTELL, 1921, p. 311;
HIRO, 1938, p. 301.

Locality. Watanoha, Miyagi-ken. VII '35. On the shell of *Pecten
laquaetus.* (O.C.I.).

Occurrence in Japan. Widely distributed in Honsyû, Shikoku, Kyûsyû
and Ryûkyû Is.

Further distribution. West Indies, European Seas, Mediterranean, West and South Africa, Indian Ocean, Malay Archipelago, New South Wales.

19. Balanus amphitrite albicostatus PILSBRY

Balanus amphitrite albicostatus: PILSBRY, 1916, p. 90; NILSSON-CANTELL, 1921, p. 314; HIRO, 1938, p. 303.
Balanus amphitrite communis: KRÜGER, 1911. p. 51 (nec DARWIN).

Localities. Pacific coast: Tôgûhama, Matusima Bay. On *Ostrea gigas.* S. NOMURA & K. HATAI. (S.H.M.); Matusima Bay. On oysters and coastal rocks. 15/X '35. F. HIRO. (M.P.C.); Oginohama, Ozika Peninsula. On *Ostrea gigas.* 15/X '35. F. HIRO. (M.P.C.); Watanoha, Miyagi-ken. On the shell of *Pecten laquaetus.* VII '35. (O.C.I.); Kadohama, Onagawa Bay. On submerged iron-plates. 21/IX '37. (O.C.I.-Sp. No. 1599); Kadohama, Onagawa Bay. On submerged iron-plates. 23/I '39. (O.C.I.-Sp. No. B-114); Ommaé Bay, near Onagawa. 26/VIII '35. (O.C.I.-Sp. No. 1109 d); Matuiwa-mura, Motoyosi-gun, Miyagi-ken. 19/IV '31. S. TADANO. (S.H.M.).

Mutsu Bay: Asamushi. On buoys of bamboo. 17/X '35. F. HIRO. (M.P.C.).

Occurrence in Japan. Widely distributed in the Japanese waters (except Hokkaidô and further northwards).

Further distribution. Hongkong, South China.

Remarks. Some of the specimens taken from the submerged iron-plates in Onagawa Bay are very interesting. The parietes are provided with many pale reddish purple-coloured narrow longitudinal stripes crossed faintly by white bands, and the interspace between these stripes is slightly raised, but not as much as in the typical *albicostatus.* The colouration closely resembles that of *Balanus trigonus* which is found in the same locality. The opercular valves correspond, however, to those of the typical *albicostatus.* Such faint colouration and the weak development of the ribs of the shell are possibly due to unusual conditions in the place of their occurrence, which is usually on the intertidal rocks only (see HIRO, 1938).

20. Balanus amphitrite hawaiiensis BROCH

Balanus amphitrite hawaiiensis: BROCH, 1922, p. 314; HIRO, 1937 b, p. 432; HIRO, 1938, p. 303; NILSSON-CANTELL, 1938, p. 40.

Locality. Kadohama, Onagawa Bay. On the submerged iron-plates. 23/I '39. (O.C.I.-Sp. No. B-114).

Occurrence in Japan. Several harbours in the mainland of Japan, all coasts of Taiwan (Formosa).

Further distribution. Malay Archipelago, Hawaiian Islands, Persian Gulf.

21. Balanus trigonus DARWIN

Balanus trigonus: DARWIN, 1854, p. 223; KRÜGER, 1911, p. 49; PILSBRY, 1916, p. 111; NILSSON-CANTELL, 1921, p. 319.
Balanus armatus: MÜLLER, 1867, p. 329; GRUVEL, 1905, p. 224.

Localities. Pacific coast: Kadohama, Onagawa Bay. On the submerged iron-plates. 21/IX '37. (O.C.I.-Sp. No. 1599); Kadohama, Onagawa Bay. On submerged iron-plates. 23/I '39. (O.C.I.-Sp. No. B-114).

Mutsu Bay: On *Fusinus*. S. HÔZAWA. (M.B.S.; HIRO, 1933, p. 551).

Japan Sea coast: Tappi-saki, Tugaru Strait. 6/V '32. N. ABE. (S.H.M.-Reg. No. 1075); Nezugaseki, Yamagata-ken. 20/X '35. F. HIRO. (M.P.C.); Toyama Bay. K. KIKUCHI. (T.H.S.); Turuga, Hukui-ken. VII '30. M. HIRAGUTI. (M.P.C.).

Occurrence in Japan. Widely distributed in all seas around Japan (except Hokkaidô and further northwards).

Further distribution. All tropical and temperate seas.

22. Balanus rostratus eurostratus BROCH

Balanus rostratus: HOEK, 1883, p. 152; PILSBRY, 1916, p. 138.
Balanus rostratus eurostratus: BROCH, 1922, p. 320; HIRO, 1932, p. 550; HIRO, 1933, p. 71.

Localities. Pacific coast: off Yuriage near Sendai, Miyagi-ken. Collected by dredging. VI '32. T. KIKUTA. (S.H.M.-Reg. No. 17480); Koyatori Bay near Onagawa. Depth 14 m. Collected by dredging. 19/VII '35. (O.C.I.-Sp. No. 758); off Izusima, Onagawa Bay. Depth 31 m. Collected by dredging. 22/VII '35. (O.C.I.-Sp. No. 842 c); off Izusima, Onagawa Bay. Depth 34 m. Collected by dredging. 23/VII '35. (O.C.I.-Sp. No. 909); Izusima, Onagawa Bay. On the shell of *Arca*, taken by the ship Hayabusa-maru 23/VI '35. (O.C.I.-Sp. No. XIII, ii, C-6); Kadohama, Onagawa Bay. On buoys of the oyster culturing station. 16/IX '36. (O.C.I.-Sp. No. B-109); Kadohama, Onagawa Bay. 23/I '39. (O.C.I.-Sp. No. B-112); Onagawa Bay. (O.C.I.-Sp. No. 1644); Samé, Aomori-ken. VII '33. Y. MURAKAMI. (S.H.M.-Reg. No. 1533); off Kuzi, Iwate-ken. Depth 168 m. (Sôyô-maru Expedition Station 59) HIRO (1933, p. 71);

near Siriya-zaki, Aomori-ken. Depth 128 m. (Sôyô-maru Expedition Station 76) Hiro (1933, p. 72).

Mutsu Bay: Moura-zima. 13/VII '33. S. Hôzawa. (T.I.U.); Asamushi. IV '25. K. Sasaki. (T.I.U.); Mutsu Bay. On the carapace of *Telmessus acutidens*. S. Hôzawa. (M.B.S.; Hiro, 1933, p. 551).

Japan Sea coast: off Kanazawa, Isikawa-ken. 22/X '35. F. Hiro. (M.P.C.).

Occurrence in Japan. Inland Sea (=Seto-naikai), Kôbe, Tôkyô and Sagami Bay, Korea Strait, Hokkaidô.

Further distribution. Northern Pacific.

Remarks. This species, forming the main part of the collections from both Onagawa and Mutsu Bays, is very common in the northern waters of Japan. Occurring in colder waters it sometimes attains to an astonishing large size, but in the warmer waters of the Inland Sea it is usually of a smaller size, not attaining to 20 mm in carinorostral diameter. The largest specimen which I have seen is from Puget Sound, Pacific coast of North America, now preserved in the museum of the Taihoku Imperial University; its carinorostral diameter is about 135 mm and the height about 100 mm.

23. Balanus rostratus dalli Pilsbry

Balanus rostratus dalli: Pilsbry, 1916, p. 147; Hiro, 1935, p. 218.

Localities. Onagawa Bay: Between Yokoura and Takasiro. 2/VI '34. Matsuzaka. (O.C.I.-Sp. No. XIII, ii, C-9); off Tako-sima. Depth 28 m. Collected by dredging. 19/VII '35. (O.C.I.-Sp. No. 738 a).

Occurrence in Japan. Hokkaidô (without exact locality).

Further distribution. Aleutian Islands, Bering Sea, Alaska.

24. Balanus cariosus (Pallas)

Balanus cariosus: Darwin, 1854, p. 273; Krüger, 1911, p. 54; Pilsbry, 1916, p. 189; Hiro, 1935, p. 223.

Localities. Onagawa Bay: Izusima. 20/VI '31. S. Hôzawa. (T.I.U.); Onagawa Bay. 4/X '32. Kamomura & Takamatsu. 4/X '32. (S.H.M.-Reg. No. 16581); Izusima. 31/VII '32. K. Iwabuchi. (S.H.M.-Reg. No. 17790); Sannôzima. 30/VII '35. (O.C.I.-Sp. Nos. 947, 956, 961, 962 h); Iigohama. 19/VIII '35. (O.C.I.-Sp. No. 1079); Konorihama. X '34. Matsuzaka. (O.C.I.-Sp. No. XIII, A, ii, C); Ommaé Bay. 26/VIII '35. (O.C.I.-Sp. No. 1112); Kadohama. On submerged iron-plates. 23/I '39. (O.C.I.).

All the material of this species were collected in the Onagawa Bay and its vicinity, which is probably the southern limit of distribution. Its absence (or scarcity) in the Mutsu Bay is of zoogeographical interest.

Occurrence in Japan. Tisima (Kurile Islands), Hokkaidô.

Further distribution. Bering Sea, Alaskan and Canadian coasts south to Oregon.

25. Balanus hesperius PILSBRY

Balanus hesperius: PILSBRY, 1916, p. 193; HIRO, 1935, p. 225.

Localities. Mutsu Bay: off Kugurizaka near Asamushi. On the shell of *Fulgoraria rupestris* (GMELIN) inhabited by a hermit crab. VII '29. D. INABA. (M.B.S.-Sp. No. 666); off Karibasawa near Nohezi. On the shell of *Natica vitellus spadicea* GMELIN inhabited by a hermit crab. VII '26. S. KOKUBO & T. KAMADA. (M.B.S.-Sp. No. 665).

Occurrence in Japan. Hokkaidô, Saghalin, Kurile Islands.

Further distribution. Alaska, Bering Sea.

Remarks. The specimens obtained in Mutsu Bay are closely identical with those of *Balanus hesperius* from Hokkaidô previously described (HIRO, 1935). The largest one attains to 18 mm in basal diameter and 6 mm in height. The parietes are glossy white, smooth and covered by a very thin, pale yellow epidermis. Their inner faces are strongly ribbed, the ribs crenated at their lower ends owing to the short longitudinal ribs on their side faces. The sheath occupies the upper 1/3 to 1/4 of the total height of the parietes; in that of the carina a distinct median ridge runs from up to the base. This is a feature not described by PILSBRY (1916) and may be one of the distinctive characteristics of this species. The radii are very broad, their summits making angles of about 45° with the base. Also the alae are broad, their summits as oblique as those of the radii. The opercular valves closely resemble those of PILSBRY's typical form from Alaska, and also its subsp. *nipponensis* from the warmer water of Japan, in the features of the closely-set growth ridges, and the remarkable sculpture of their inner faces. The inner parts are not much different from the original description of the typical form.

In comparison with those specimens, some notes may be added as to the specimens taken from the other localities. A series from Taraika, southern Saghalin, attached to the test of tunicates, which was collected by the late S. TAKAHASHI is externally of the smooth form; its basal diameter 5–5.5 mm and height about 3 mm. Their scuta have the basal

margin longer than the tergal margin, and have the distinct but widely-spaced growth ridges, as in those of the ribbed forms from off Kamchatka, drawn by PILSBRY (1916, pl. 49, fig. 7 a). The internal sculpture is more like that of forma *laevidomus*. Another series from Paramusiru Is., the northern Kuriles, growing on the shell of *Neptunea lirata* (MARTYN) contains the conic ribbed form. The opercular valves are similar to those of the smooth form from Mutsu Bay.

26. Acasta japonica PILSBRY

Acasta spongites japonica: PILSBRY, 1911, p. 80.
Acasta japonica: PILSBRY, 1916, p. 243; BROCH, 1922, p. 330.

Locality. Toyama Bay. Imbedded in a sponge. '37. K. KIKUCHI. (M.P.C.).

Occurrence in Japan. Kagosima Gulf, Sagami Bay.

Further distribution. Malay Archipelago.

Remarks. Some dry specimens of the genus *Acasta* from Toyama Bay are determined as *Acasta japonica*, which is nearly related to *Acasta spongites*. The external differences are clearly pointed out by PILSBRY (1916). I have also been able to compare these with the other allied species, e. g. *Acasta sulcata* and *A. fenestrata*. The carino-basal margin of the tergum is always as long as the upper carinal margin, and parallel to the lower half of the scutal margin. The spur is narrow, long and roundly ending, and also the apex is strongly beak-like; these are the most important differential characters of species.

Subfamily Tetraclitinae NILSSON-CANTELL
27. Tetraclita squamosa japonica PILSBRY

Tetraclita squamosa japonica: PILSBRY, 1916, p. 252.
Tetraclita porosa japonica: NILSSON-CANTELL, 1932, p. 27.

Localities. Pacific coast: Hûkiura, Ozika Peninsula. 30/VIII '21. (T.I.U.); Ozaki, mouth of Watanoha Bay, Miyagi-ken. 15/VIII '31. T. TAKEDA. (S.H.M.); Azi-sima, S.W. of Ozika Peninsula. 8/IV '32. Sh. OHFUCHI. (S.H.M.-Reg. No. 16480); Onagawa Bay. 4/X '32. KAMOMURA & T. TAKAMATSU. (S.H.M.-Reg. No. 16581); Nakasima, Onagawa Bay. 1/VII '35. K. KIMURA. (O.C.I.-Sp. No. XIII, ii, C-1); Onagawa Bay. (O.C.I.-Sp. Nos. 1037, 1137); Miyagazaki, Onagawa Bay. 16/VIII '35. (O.C.I.-Sp. No. 1034); Sannô-zima. 30/VII '35. (O.C.I.-Sp. No. 946); Torisima, Onagawa

Bay. 16/VI '35. K. KIMURA. (O.C.I.-Sp. No. XIII, ii, C-7).

Mutsu Bay: Hutago-zima. S. HÔZAWA. (M.B.S.; HIRO, 1932, p. 551).

Japan Sea coast: Tappi-saki, Tugaru Strait. 22/VII '29. S. HÔZAWA. (M.B.S.-Sp. No. 2499); Kuraga-mura, Akita-ken. 23/VIII '32. S. ONO. (S.H.M.-Reg. No. 572); Ryôzu, Is. of Sado. 18/VII '32. M. TOKUDA. (M.P.C.); Nezugaseki, Yamagata-ken. 20/X '35. F. HIRO. (M.P.C.); Tôzinbô, Hukui-ken. K. KIKUCHI. (T.H.S.).

Occurrence in Japan. Widely distributed in the mainland of Japan.

28. Tetraclita darwini PILSBRY

Tetraclita darwini : PILSBRY, 1928, p. 314.

Locality. Toyama Bay. Depth 100 m. K. KIKUCHI. (T.H.S.).

Occurrence in Japan. Hirado (PILSBRY), Seto (HIRO), northern Japan (NILSSON-CANTELL).

This species is a remarkable form possibly endemic to Japan, since aside from the known localities mentioned above I have specimens came from various different localities of Japan.

Subfamily Chelonibiinae PILSBRY

29. Chelonibia testudinaria (LINNÉ)

Chelonobia testudinaria : DARWIN, 1854, p. 392; KRÜGER, 1911, p. 57.
Chelonibia testudinaria : PILSBRY, 1916, p. 264; NILSSON-CANTELL, 1921, p. 369; HIRO, 1937 b, p. 470.

Locality. Toyama Bay. On the carapace of *Caretta olivacea.* K. KIKUCHI. (T.H.S.).

Distribution. All tropical and warm temperate seas. Attached to turtles.

Subfamily Coronulinae GRAY

30. Coronula diadema (LINNÉ)

Coronula diadema : DARWIN, 1854, p. 417; PILSBRY, 1916, p. 273; NILSSON-CANTELL, 1921, p. 371; CORNWALL, 1927, p. 504; HIRO, 1937 b, p. 504.

Localities. Samé, Aomori-ken. On the skin of *Megaptera nodosa.* 28/VII '32. Y. MURAKAMI. (S.H.M.-Reg. No. 1309); Ayukawa, Miyagi-ken. On the skin of *Megaptera nodosa.* 15/X '35. F. HIRO. (M.P.C.).

Distribution. All the seas. Attached to whales.

TABLE I

Distribution of cirripeds occurring in northern Honsyû	Northern Honsyû			Hokkaidô, Kurile Is. & further northward	Middle & southern Japan	Indo-Malayan region
	Japan Sea side	Mutu Bay	Pacific coast			
Mitella mitella	×	×	×	(×)	×	×
Calantica scorpio	×	•	•	•	×	×
Scalpellum stearnsi	•	•	×	•	×	×
Lepas anatifera	×	×	×	×	×	×
· · · anserifera	×	•	•	×	×	×
—— pectinata	•	•	×	×	×	×
—— fascicularis	•	•	×	×	×	×
Conchoderma auritum	•	•	×	×	×	×
—— virgatum	•	•	×	×	×	×
—— virgatum hunteri	×	•	•	•	×	×
Heteralepas (Paralepas) minuta	×	•	•	•	•	× ?
Octolasmis weberi	×	•	•	•	×	×
—— lowei	•	×	•	•	•	×
Chthamalus challengeri	×	×	×	(×)	×	×
Octomeris sulcata	×	•	•	•	×	•
Balanus tintinnabulum volcano	×	•	•	•	×	× ?
—— tintinnabulum rosa	×	×	×	•	×	•
—— amphitrite communis	•	•	×	•	×	×
—— amphitrite albicostatus	•	×	×	•	×	•
—— amphitrite hawaiiensis	×	•	×	•	×	×
—— trigonus	×	×	×	•	×	×
—— rostratus eurostratus	×	×	×	×	×	•
—— rostratus dalli	•	•	×	×	•	•
—— cariosus	•	•	×	×	•	•
—— hesperius	•	×	•	×	•	•
Acasta japonica	×	•	•	•	×	×
Tetraclita squamosa japonica	×	×	×	•	×	•
—— darwini	×	•	•	•	×	•
Chelonibia testudinaria	×	•	•	•	×	×
Coronula diadema	•	•	×	×	×	×

× in ( )=found at the southernmost of Hokkaidô only.

GENERAL REMARKS

The present paper comprises 30 different forms, if varieties and sub-species are also included, of the Cirripedia, which have been found on

the coasts around the Tôhoku and Hokuriku districts, northern Honsyû. All of them are already known in the northwestern Pacific, and consist of the following 4 elements classified according to their geographical distribution :

TABLE II

Synopsis of the distributional elements	Number of species	
	Northern Honsyû	Hokkaidô & Kuriles
Cosmopolitan, or widely distributed in all seas	11	5
Distributed in Japan and the Indo-Malayan region	8	3
Endemic to, or known only in Japan	6	0
Distributed in northern Pacific or boreal waters	4	9
Total	29	17

In addition, only one species, *Heteralepas* (*Paralepas*) *minuta*, shows a limited distribution.   Its natural habitat is the coast around the north-west Africa, but it has been found on the west coast of northern Honsyû (see HIRO, 1933), which is very distant from the original locality.

As is shown in Table II, the boreal forms occurring in northern Honsyû are represented by only 4 varieties, amounting to 13% of the total number of species ; in Hokkaidô and the Kurile Islands, however, they occupy half of all the fauna (see HIRO, 1935).   They are *Blanus rostratus eurostratus*, *B. rostratus dalli*, *B. hesperius* and *B. cariosus*, all living in the sublittoral region.   It is of special notice that *B. cariosus* is very commonly found in Onagawa Bay on the Pacific coast, but does not occur in Mutsu Bay and other localities of northern Honsyû, though *B. rostratus* is very common on all the coasts of these districts.   The latter species is rather widely distributed along the colder northern coast of Honsyû, and extends as far as south as the Inland Sea.   The other boreal forms living in Hokkaidô, such as *B. crenatus*, *B. balanoides* and *Chthamalus dalii*, have not been found on the coasts of Honsyû.

There is no marked difference between the cirripedian fauna of the Japan Sea coast and that of the Pacific coast.   Still it is of some interest to find occurring along the Japan Sea coast forms apparently endemic to the southern part of Japan, such as *Octomeris sulcata* and *Balanus tintinnabulum volcano*.   As to the southward extension in distribution of the boreal forms, along the western coast of Honsyû, our knowledge is very meagre, as the material of such boreal forms, except one *B. rostratus*,

dealt with in this paper, was all taken from the eastern or Pacific coast. From available literature, however, it seems certain that as far as the Cirripedia is concerned, there exists no such definite faunal demarcation between the northwards and southwards distributing forms in the region of the Noto Peninsula, as is the case in the Mollusca, Brachiopoda and Decapod Crustacean (see NOMURA & HATAI, 1936, 1937).

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ANNELIDA POLYCHAETA IN ONAGAWA BAY AND ITS VICINITY
II. POLYCHAETA ERRANTIA WITH SOME ADDENDA OF POLYCHAETA SEDENTARIA

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(With 14 figures)

(Received April 26, 1939)

In this paper has been recorded the results of a study of Polychaeta Errantia possessed by the Onagawa Oceanochemical Institute of the Tôhoku Imperial University, which were kindly submitted to me by several posts by Dr. TAKEO IMAI of the Institute. A report of the representatives of the Polychaeta Sedentaria has already been published in this Journal (1937, vol. 12, no. 1). Some sedentary polychaetes unrecorded in the former report, which were sent to me after the previous paper was published, have also been treated in this paper. Here I have examined 28 species of Polychaeta Errantia appended with 11 sedentary worms. The total number of the species furnished by Dr. T. IMAI was 62, including two new species, a single new variety, and 14 species newly found in Japanese waters. Our knowledge of the polychaete fauna of Northern Japan is still rather meagre. Only several scattered records have been published by GRUBE (1877), MOORE (1903), IZUKA (1912), FRICKHINGER (1916), NILSSON (1928) and OKUDA (1934, 1936, 1937 and 1938). In his preliminary report on the Japanese polychaetes (Amphinomidae and Aphroditidae) collected by Prof. F. DOFLEIN, FRICKHINGER (1916) stated that some material was collected from Onagawa Harbour, but he made no further mention as to what species were derived actually from that locality, and unfortunately nothing more has been published concerning DOFLEIN's polychaetes collection. Most of the species treated here are widely distributed in Southern Japan, but some species are boreal forms. It may be worth noticing that there were no specimens of the genus *Eunice* which are dominantly found in warm waters. In the following I have given the complete list of polychaetes found in Onagawa Bay and its vicinity. The sedentary polychaetes reported newly in this paper are indicated with an asterisk.

Family Amphinomidae

Euphrosyne superba MARENZELLER

Family Aphroditidae

Aphrodite aculeata LINNÉ

Laetmatonice japonica McINTOSH

Laetamatonice producta var. *benthaliana* McINTOSH

Lepidonotus helotypus (GRUBE)

Harmothoë imbricata (LINNÉ)

Eunoë Hozawai, n. sp.

Lepidasthenia longissima (IZUKA)

Euthalenessa oculata (McINTOSH)

Family Phyllodocidae

Eulalia (Eumida) sanguinea (OERSTED)

Notophyllum imbricatum MOORE

Family Nereidae

Nereis Izukai, n. sp.

Nereis ezoensis IZUKA

Nereis pelagica LINNÉ

Perinereis nuntia var. *brevicirris* GRUBE

Family Nephthydidae

Nephthys caeca var. *ciliata* McINTOSH

Nephthys longisetosa OERSTED

Family Glyceridae

Glycera rouxii AUDOUIN et M. EDWARDS

Glycera opisthobranchiata MARENZELLER

Glycera robusta EHLERS

Goniada maculata OERSTED

Hemipodus borealis JOHNSON

Family Eunicidae

Marphysa sanguinea MONTAGU

Onuphis conchylega SARS

Diopatra neapolitana DELLE CHIAJE

Lumbriconereis latreilli AUDOUIN et M. EDWARDS

Arabella iricolor (MONTAGU)

Arabella geniculata var. *japonica*, n. var.

Family Ariciidae

Haploscoloplos kerguelensis (McINTOSH)

Aricia fimbriata MOORE
    Family Spionidae
Prionospio pinnata EHLERS
    Family Magelonidae
Magelona japonica OKUDA
    Family Chaetopteridae
Spiochaetopterus sp.
    Family Cirratulidae
ᐟ*Audouinia comosa* (MARENZELLER)
Chaetozone spinosa MOORE
    Family Chloraemidae
Stylarioides plumosa (O. F. MÜLLER)
Brada villosa (RATHKE)
    Family Arenicolidae
Arenicola cristata STIMPSON
    Family Maldanidae
Asychis gotoi (IZUKA)
Maldane sarsi MALMGREN
Stylarioides eruca (CLAPARÈDE)
Brada villosa (RATHKE)
    Family Amphictenidae
Pectinaria hyperborea MALMGREN
    Family Owenidae
* *Owenia fusiformis* DELLE CHIAJE
    Family Terebellidae
* *Amphitrite edwardsi* (QUATREFAGES)
Amphitrite cirrata (O. F. MÜLLER)
Amphitrite rubra (RISSO)
Polymnia nebulosa (MONTAGU)
Pista elongata MOORE
Thelepus setosus (QUATREFAGES)
    Family Sabellidae
Potamilla reniformis (O. F. MÜLLER)
Potamilla myriops MARENZELLER
* *Sabella aulanconota* MARENZELLER
* *Sabella melanostigma* SCHMARDA

Sabella sp.
* *Dasychone cingulata* GRUBE
* *Myxicola infundibulum* (RENIER)

Family Serpulidae

Hydroides uncinata (PHILIPPI)
* *Hydroides ezoensis* OKUDA
Pomatoleios crosslandi PIXELL
Salmacina dysteri (HUXLEY)
Spirorbis nipponicus OKUDA

Before proceeding further my hearty thanks are due to Dr. TAKEO IMAI who placed the valuable collection at my disposal and also to Prof. TOHRU UCHIDA for his kind guidance in the course of the investigation.

DESCRIPTION OF THE SPECIES

Family Amphinomidae

Euphrosyne superba MARENZELLER

(Fig. 1)

MARENZELLER, 1875, p. 2, pl. 1, fig. 1.

Occurrence: Koshiki-Nè. Collected by dredging. Sp. No. H. 70.

A single rather small specimen in a contracted state measures 22 mm by 7 mm for the 38 setigerous segments. The present specimen is different from the species described by MARENZELLER in having a pair of a row of 9 branchial tufts on each segment instead of 8 and in the position of the lateral cirrus which is situated between the 4th and 5th branchiae instead of between the 3rd and 4th branchial tufts. As to the other characteristics such as the position and length of the caruncle, the shape of the bristles and the branchiae the present specimen corresponds well with MARENZELLER's species. As far as the number of the branchiae and the position of the lateral dorsal cirrus are concerned, the present specimen is very like *Euphrosyne heterobranchia* from which it is distinguished by the shape of the dorsal setae. In some species of the genus the number of branchiae and the position of the lateral dorsal cirrus seem to be variable to some extent as is shown in *Euphrosyne dumosa* MOORE, in which the number of branchiae is usually 10, but sometimes 9 or 11, and the lateral dorsal cirrus is situated between the 3rd and 4th or between the 4th and 5th branchiae. The identification

of the present specimen with the species is somewhat doubtful.

Family Aphroditidae
Subfamily Hermioninae
Aphrodite aculeata LINNÉ

Aphrodite aculeata: FAUVEL, 1923, p. 33, fig. 10, a–g; TAKA-HASHI, 1938, p. 195, pl. 20, B; Text-fig. 1.

Aphrodita japonica: MARENZELLER, 1879, p, 3, pl. 1, fig. 2.

Occurrence: Torishima; Oura-Inlet. Collected by dredging. Sp. No. H. 69; 1544.

Two specimens were collected.

Laetmatonice japonica McINTOSH

IZUKA, 1912, p. 80, pl. 1, fig. 4; pl. 9, figs. 14–15; FAUVEL, 1936, p. 48. TAKAHASHI, 1938, p. 198, Text-fig 3.

Occurrence: Shirane-Saki. Collected by dredging. Sp. No. H. 67.

Of two specimens the larger one measures 30 mm for 34 setigerous segments. The species is widely distributed along the coasts of Japan.

Fig. 1. *Euphrosyne superba* MARENZELLER. a, Branchia. ×45; b, c, Dorsal setae. ×200; c, d, Ventral setae. ×200.

Laetmatonice producta GRUBE var. benthaliana McINTOSH

IZUKA, 1912, p. 84, pl. 9, figs. 7–10; OKUDA, 1938, p. 82, fig. 4.

Occurrence: Off Enoshima: Collected by trawlmg, 150 m. Sp. No. H. 243.

A single complete specimen measures 52 mm. Scales in 17 pairs. The dorsal felt is lacking.

Subfamily Polynoinae
Lepidonotus helotypus (GRUBE)

Lepidonotus helotypus: SEIDLER, 1924, p. 56; FAUVEL, 1933, p. 8.
Polynoë gymnonotus: MARENZELLER, 1789, p. 112, pl. 1, fig. 3; IZUKA, 1912, p. 8, pl. 3, figs. 1–4.

Occurrence: Miyagasaki: Sandy bottom. Sp. No. H. 83.

Three specimens were examined. In the preserved state the scales of two specimens are reddish brown and those of the other black. The largest specimen measures 44 mm for 26 setigerous segments. The nephridial papillae occur first on the 8th segment. This is one of the common species in Japanese waters, distributed from Sakhalin to Southern Japan. SEIDLER considered that *L. dofleini* recorded by FRICKHINGER (1916) may be synonymous with the present species.

Harmothoë imbricata (LINNÉ)

IZUKA, 1912, p. 43, pl. 5, figs. 1–4; pl. 6, fig. 1.

Occurrence: Takeno-Ura; Takoshima; Oiso-Saki. Collected by dredging. Sp. No. H. 81; H. 89; H. 90.

Eunoë Hozawai, n. sp.
(Figs. 2-3)

Occurrence: Oura-Inlet. Sp. No. H. 68.

A single specimen measuring 48 mm by 16 mm including parapodia. There are 15 pairs of elytra and 40 segments. All elytra except two were lost. The prostomium is about 2.5 times broader than long. Both the median and left lateral tentacles are injured. The palpi are stout, about two and a half times the length of the lateral tentacle, tapering gradually to a slender end. The entire surface of the palpi is densely beset with long filiform papillae. The lateral tentacle is about 3 times the length of the prostomium. The tentacular cirri are slightly shorter than the palpi. Both the lateral tentacle and the tentacular cirri have subterminal bulged portions and filiform ends. There are 5 unidentate simple curved serrated setae at the base of the tentacular cirri. The two pairs of well developed eyes are situated far back on the prostomium. The elytra are attached to segments 2, 4, 5, 7···23, 26, 29, 32. They are broadly oblong, and are ornamented with stout, branched spinous tubercles limited mainly to the posterior and lateral margins,

about 3/4 of the entire margin of the elytra, which are also fringed with long papillae. On the surface of the elytra small, simple or bifurcated,
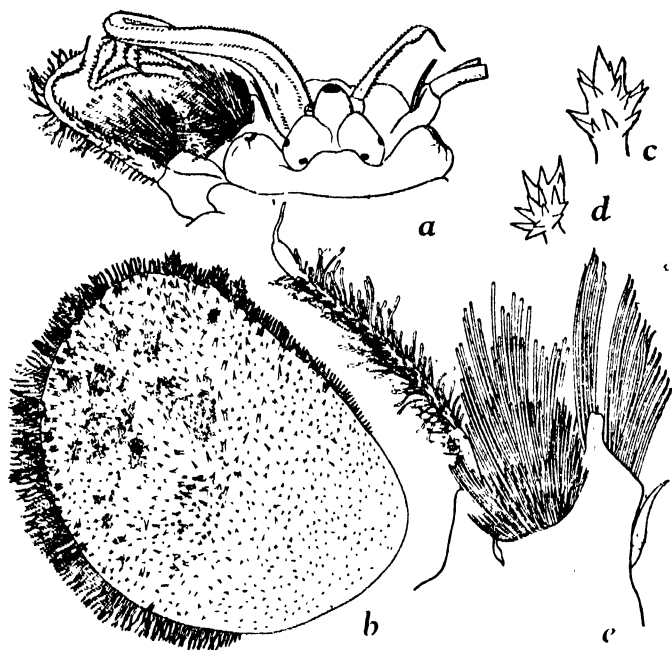
Fig. 2. *Eunoë Hozawai*, n. sp. a, Anterior end omitted on the right side. ×7; b, Elytron. × ; c-d, Spinous tubercles from elytron. ×25; e, 16th parapodium. ×25.

spine-like tubercles are scattered. The parapodium, well developed and elongated, is divided into two unequal rami, both of which bear a long, cylindrical finger-like terminal piece. The dorsal cirrus is long, markedly elongated with subterminal dilation, being thickly fringed with long, villous papillae. The ventral cirrus is smooth, not reaching the tip of the ventral ramus. The dorsal setae are arranged in 4–5 transverse rows, of which the setae of the first row consist of simple hooked setae each with a sharp end. In the second row there are two kinds of setae; those of the most dorsal portion are long, stout setae being serrated minutely on their whole exposed length, the terminal ends of which are more or less truncated, flattened, resembling somewhat those of *Harmothoë crassicirrata*, while the setae of the median and ventral portion are of a similar kind with those of the first row, but much longer. The other 3 upper rows are composed only of truncated, stout setae. The ventral
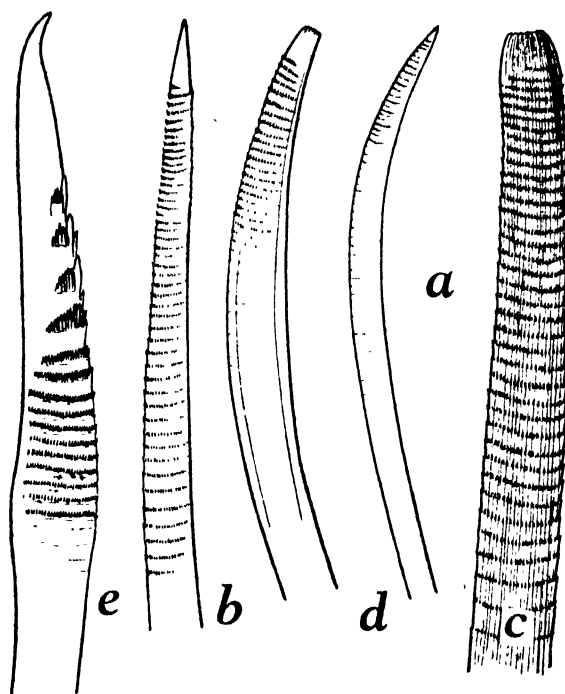
Fig. 3. *Eunoë Hozawai* n. sp. a, b, Dorsal setae with sharp ends. ×125; c, d, The same with truncated terminal ends. ×125; e, Ventral setae. ×125.

setae are as usual in the genus. They are unidentate, with spinous rows and a simply bent hook-like tip. The nephridial papillae begin to occur on the 6th segment. They are low mammiliform.

Remarks: The species is characterised by the dense papillation and well developed spinous tuberculation of the elytra and by the shape of the dorsal setae with a truncated terminal end. Though *Eunoë oerstedi* reported by MALMGREN is closely allied to this species, it can be distinguished in the characteristics above mentioned. *Eunoë yedoensis* recorded from Japan is also different in lacking the spinigerous processes on the elytra and in the shape of the dorsal setae. The name of this new species has been chosen in honour of Prof. S. HOZAWA.

Lepidasthenia longissima (IZUKA)

Polynoë longissima: IZUKA, 1912, p. 34, pl. 1, fig. 1; pl. 4, figs. 1-5.
Lepidasthenia longissima: OKUDA, 1936, p. 568, figs. 6-7.

Occurrence: Onagawa Harbour. Collected by dredging. Sp. No. H. 79.

Subfamily Sigalinoninae
Euthalenessa oculata (McINTOSH)

Thalenessa oculata: IZUKA, 1912, p. 86, pl. 10, figs. 1-2.

Occurrence: Yoriso Bay. Collected by dredging. Sp. No. H. 131.

Family Phyllodocidae
Eulalia (Eumida) sanguinea (OERSTED)

FAUVEL, 1936, p. 58; OKUDA, 1938, p. 88, fig. 9.

Occurrence: Ommaé-Bay. Collected by dredging. Sp. No. 139.

Notophyllum imbricatum MOORE
(Fig. 4)

MOORE, 1906, p. 217, pl. 10, figs. 1–3; FAUVEL, 1936, p. 59.

Occurrence: Samenoura. Collected by dredging. Sp. No. H. 134.

Two specimens, both of which are incomplete in the posterior body. Excepting the number of nuchal processes the specimens agree with MOORE's species. The specimens have only two nuchal processes instead of three as is shown in the species. The nuchal processes are finger-shaped, well developed, of which the inner process is shorter than the outer. The characteristics of tentacles and tentacular cirri correspond well with MOORE's description. The dorsal ramus of the parapodium bears a single capillary fine seta. In Japan two species, *N. japonicum* and *N. sagamianum*, both belonging to the genus are recorded. The former species is considered to be synonymous with *N. foliosum*, though somewhat doubtful as to characteristics

Fig. 4. *Notophyllum imbricatum* MOORE.
a, Anterior end; b, Parapodium.

of the nuchal process, and the latter species has four long nuchal processes and tentacular cirri different from the present species. *N. foliosum* bears only a single pair of nuchal processes. As regards the processes the specimens are in the intermediate state between *N. foliosium* and *N. imbricatum.*

Family Nereidae
Nereis Izukai, n. sp.
(Fig. 5)

Occurrence: Off Kinkasan. 130 fms. Collected by trawling. Sp. No. H. 202.

A single complete specimen measures 91 mm by 5 mm excluding parapodia. There are 90 setigerous segments. Tentacles in a pair are slender, each tapering to a sharp end, and are about 2/3 of the length of the head. The prostomium is more or less flattened at the anterior end. *There is no trace of eyes and no pigmentation.* Palpi in a pair, stout, inflated in the basal portion with a knob-like palpophore, are about twice
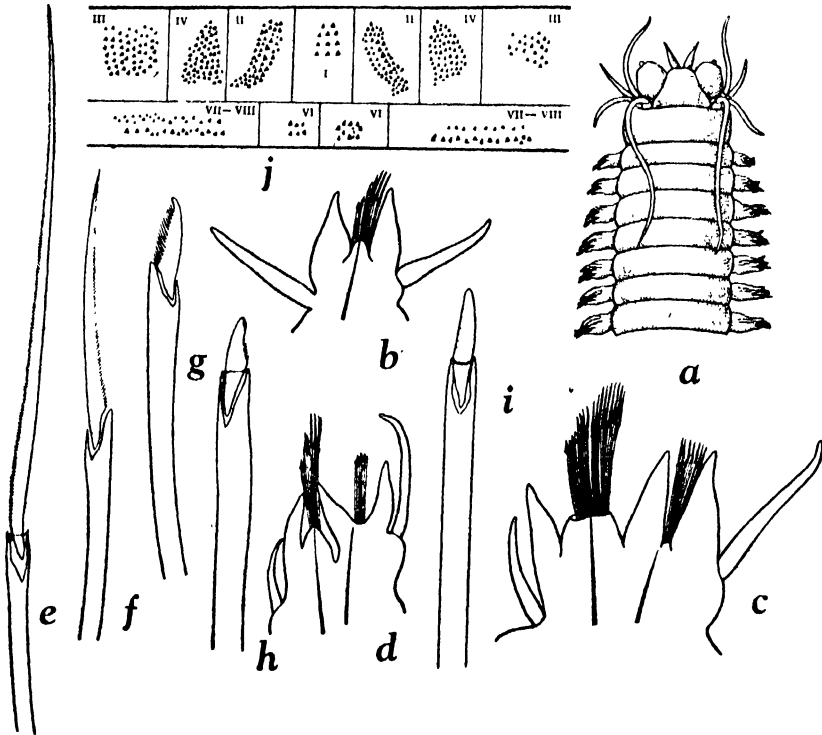
Fig. 5. *Nereis Izukai,* n. sp. a, Anterior end. ×4; b, 1st parapodium. ×15; c, 10th parapodium. ×15; d, 75th parapodium. ×15; e, Homogomph spinigerous seta. ×200; f, Heterogomph spinigerous seta. ×200; g, Heterogomph falcate seta. ×200; h, Homogomph falcate seta from posterior parapodium. ×200; i, The same with rod-shaped apex. ×200; j, Paragnathi from dissected proboscis.

as long as the tentacles. Tentacular cirri in 4 pairs; the most anterior cirri are short and similar in form with the tentacles. The longest tentacular cirri attain as far back as the 5th setigerous segment. The buccal segment is about one half the length of the next setigerous segment. The proboscis was not everted, and therefore was examined by dissection. The distribution of paragnathi is as follows; Group I, with 11 teeth in triple rows; Group II, with about 52–56 paragnathi on each side arranged roughly in 4 oblique rows; Group III, with about 70 paragnathi in broad clusters; Group IV, with 50–60 paragnathi on each side, in a triangular clusters; Group V, absent; Group VI, with 12 paragnathi on the right side and 6 on the left, arranged in an oval group; Group VII–VIII, with a continuous band of double rows; the paragnathi of the upper band smaller, about 31 in number, and those of the lower one about 32. The jaws are dark brown with 5–6 teeth on each inner edge The parapodia from the first to the 6th pair increase in size. In the first and 2nd parapodia there are no dorsal setigerous divisions. The first parapodium is relatively large. The dorsal cirrus is a little longer than the ventral one. Both are well elongated, slender and longer than the dorsal and ventral ligules. The dorsal ligule is almost similar in size to the ventral one which is rather slender and lanceolate. The setae may be divided into three groups; two are placed below the acicular spine and the other one above the same. In the upper setae-group there are a small number of homogomph spinigers only, while in the lower group there are found one or two heterogomph spinigers and heterogomph falcigers. The 2nd parapodium resembles the first, but has a little longer dorsal cirrus and setigerous lobe. The dorsal setigerous division appears first in the 3rd parapodium, and the setae of the dorsal median fillet consist of only homogomph spinigers. The 10th parapodium exhibits the normal condition. The dorsal cirrus is long, surpassing the dorsal ligule, while the ventral cirrus is small, not attaining to the tip of the ventral ligule. The dorsal and median ligules are similar in size, both being thicker and slightly longer than the ventral ligule. In the ventral division the fillet is cylindrical and is well developed, having a prominent pointed anterior lobe and a rounded posterior lobe. In the dorsal division the fillet is small and rounded. The setae in the dorsal ramus are all homogomph spinigers, while those in the ventral one are comprised of three types of setae; a number of heterogomph falcate setae and a small number of heterogomph spinigers (5–6) below the aciculum, and a fair number of homogoph spinigers and 2 or 3 heterogomph falcigers above the aciculum.

In the 20th parapodium the dorsal cirrus is long and slender, while the ventral cirrus is much smaller. The dorsal ligule is more elongated and longer than the median ligule. The distribution of setae is similar to that of the 10th parapodium. In the 50th parapodium the dorsal ligule partially merges into the median ligule. In the 75th parapodium the dorsal cirrus is slender, and is more elongated than the dorsal ligule. The ventral cirrus is about half the length of the ventral ligule. All of the ligules are almost similar in size, slender and pointed. From about the middle body backwards (40th–50th segments) there occur homogomph falcigers in the dorsal fillets. In the posterior body the dorsal setae are represented by only these homogomph falcigers instead of homogomph spinigers. Homogomph falcigers situated in the dorsal division have each a short apex with 5–6 stout teeth, while those in the ventral division bear a rod-like apex with faint serrations.

Remarks : The species can be characterized by the entire absence of eyes, the armature of the proboscis and the characteristic parapodium. The species has been named in honour of the late Prof. A. IZUKA who made many contributions to the study of Japanese Polychaete worm.

Nereis ezoensis IZUKA

IZUKA, 1912, p. 173, pl. 18, figs. 12–20.

Occurrence : Ishihama. Sp. No. H. 99 ; H. 108.

Nereis pelagica LINNÉ

FAUVEL, 1923, p. 336, fig. 130, a–f.

Occurrence : Yataro-Iso. Sp. No. H. 108.

A single complete specimen measures 82 mm by 5 mm. The armature of the proboscis was as follows : Group I, with 3 paragnathi in a longitudinal line ; Group II, with about 14–15 teeth in 3 irregular oblique rows ; Group III, with about 16 paragnathi arranged in a cluster ; Group IV, with 8 transverse row, 2–5 paragnathi in each row ; Group V, absent ; Group VI, with 4 paragnathi in an oval shape ; Group VII–VIII, with several irregular continuous bands, paragnathi of the uppermost band are stouter and larger than the others. The bristles on the dorsal ligule are all homogomph spinigers which are replaced by homogomph falcigers in the posterior parapodia. These homogomph falcigers each bear a bluntly rod-shaped apex. In ventral ramus there are homogomph spinigers and heterogomph falcigers in the superior division and heterogomph falcigers in the inferior division.

Perinereis nuntia (SAVIGNY) var. brevicirris GRUBE

Nereis mictodonta: MARENZELLER, 1879, p1. 118, pl. 2, fig. 2.

Occurrence: Takoshima; Kirigasaki; Ishihama; Takenoura. Sp. No. H. 71; H. 100; H. 99; H. 105; H. 107.

Family Nephthydidae

Nephthys caeca (FABRICIUS) var. ciliata McINTOSH

(Fig. 6)

HEINEN, 1911, p. 13, fig. 2.

Occurrence: Ommae Bay. Sp. No. 114.

A fair number of specimens were observed. The largest specimen measures 84 mm by 3 mm excluding parapodia. The proboscis is furnished with 22 rows of soft papillae, generally 6 in each row. There is no median papilla. The dorsal ramus of the parapodium has a rounded anterior lamella which is distinctly divided into two lobes by an incision and a small rounded posterior lamella. There is a short, cirriform process at the base of the branchia coiled inwards. In the ventral ramus the anterior lamella is entire, and the posterior lamella is longer than that of the dorsal ramus, but is not so elongated as is shown in HEINEN's figure. The bristles are markedly long, slender.
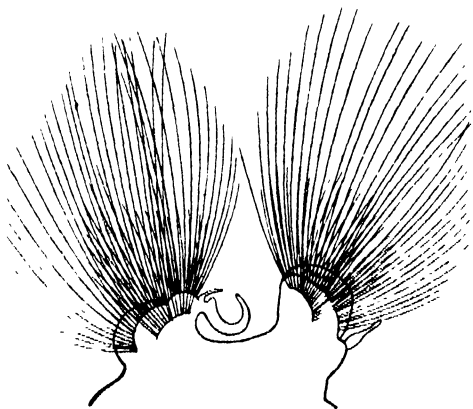
Fig. 6. *Nephthys caeca* (FABRICIUS) var. *ciliata* McINTOSH. Parapodium from about 45th segment. ×18.

Nephthys longisetosa OERSTED

HEINEN, 1911, p. 26, fig. 7.

Occurrence: Takoshima. Collected by dredging. Sp. No. H. 118.

A single poorly-preserved specimen separated into two body-fragments. The proboscis bears 22 rows of papillae, 2 or 3 in a single row. There is a median papilla. In the typical parapodium both the dorsal and ventral rami are widely apart. In the dorsal ramus the posterior mem-

branous lamella is low, rounded in outline, and the anterior lamella is also smooth and has no incision such as is usually shown in *N. ciliata*. The dorsal cirrus is short. The branchiae occur first from the 3rd setigerous segment (?). They are long and coiled inwards. In the ventral ramus the posterior lamella is also rounded, more or less cone-shaped, and the anterior lamella is oval, without any incision such as is generally found in European specimens. The dorsal and ventral setae are markedly elongated and slender. Compared with the common species, *N. ciliata*, which is widely distributed in Japan, the present specimen is different in feature of the parapodium. As to the weak development of the posterior lamella of the ventral rami the present specimen resembles *N. incisa*, but the anterior lobe is oval, rounded and not conical. I have attributed the present specimen to the species with some doubts.
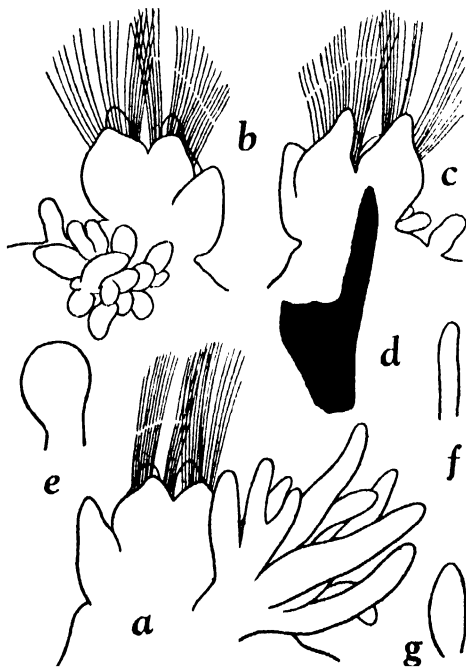
Fig. 7. *Glycera opisthobranchiata* MAREN-ZELLER. a, b, Parapodia from behind, showing different states of branchiae. × 20; c, Parapodium from in front. × 20; d, Jaw-support. × 30; e–f, Various kinds of papillae from proboscis. × 130.

Family Glyceridae

Glycera rouxii AUDOUIN et M. EDWARDS

FAUVEL, 1936, p. 70; OKUDA, 1937, p. 275.

Occurrence: Onagawa Harbour; Ayukawa Bay. Sp. No. H. 98; H. 97.

Glycera opisthobranchiata MARENZELLER

(Fig. 7)

MARENZELLER, 1879, p. 31, pl. 6, fig. 2; FAUVEL, 1936, p. 71.

Occurrence: Okachi Bay; Onagawa Harbour. Collected by dredging. Sp. No. H. 94; H. 96; H. 113; H. 117.

The papillae of the proboscis consist of two kinds; one low, oval and the other slender and cylindrical in shape. The larger, oval papillae are

sparsely distributed among the slender cylindrical ones. The parapodium bears two posterior subequal lobes and two anterior bluntly cone-shaped ones. The branchiae are retractile. They are finger-like, thin-walled lobes, dendroidly branched, and are attached to the posterior portion of the parapodium near the base of the dorsal cirrus. The support of the jaw has a well developed, elongated process. *Glycera misakiensis* described by IZUKA is closely allied to the species.

Glycera robusta EHLERS

IZUKA, 1912, p. 248, pl. 23, fig. 10; MOORE, 1903, p. 464.

Occurrence: Nakanoshima. Collected by dredging. Sp. No. 1306.

Two giant specimens, both being incomplete in the posterior body. As MOORE mentioned these specimens also have the colony of dichotomously branched ciliates between the interspace of the parapodia.

Goniada maculata OERSTED
(Fig. 8)

EHLERS, 1868, p. 704, pl. 24, figs. 36–48; ARWIDSSON, 1898, p. 36, pl. 2, figs. 25–28; pl. 4, figs. 60–61; FAUVEL, 1923, p. 392, fig. 154, a–g.

Occurrence: Takoshima. Collected by dredging. Sp. No. H. 95.

A single rather small complete specimen measures about 50 mm. The body is divided into the anterior cylindrical and posterior more or less flattened portions. The prostomium bears 10 annuli. No eyes were found. Four small tentacles. On each side of the base of the proboscis is a series of 10 V-shaped paragnathi. There are 18 obtuse lobes at the extreme end of the proboscis fully protruded. Two principal horny jaws are 8-toothed. In the dorsal interspace between the two principal jaws are 4 x-shaped paragnathi, which correspond well in shape with EHLERS' figure. In the ventral interval between the principal jaws there are 3 paragnathi (Fig. 8, f). The papillae on the proboscis are heart-shaped. The first 40 segments were uniramous. The dorsal bristles are simple while the ventral ones are compound. The present species is easily distinguished from the other Japanese species, such as *G. japonica* (=*G. emertia*), *G. distorta* and *G. foliacea*, by the smaller number of dorsal and ventral paragnathi situated between the principal jaws. Though the species is rather commonly found in European cold waters it has not yet been recorded from Japan.
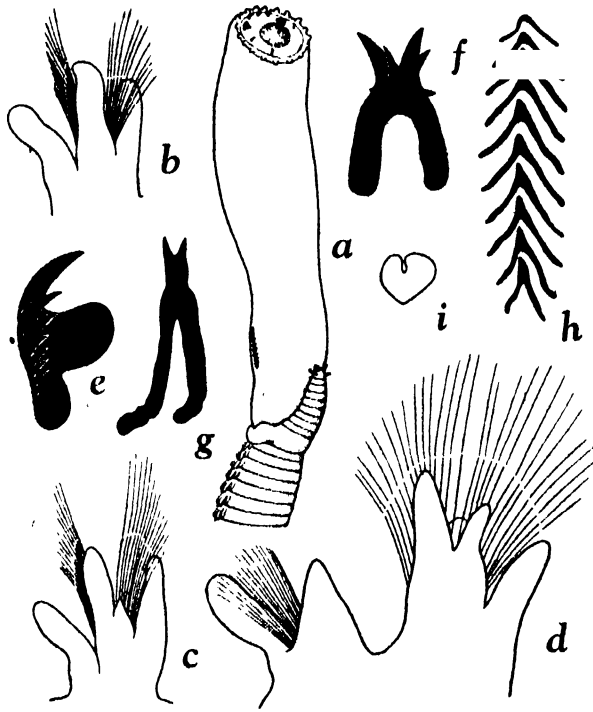
Fig. 8. *Goniada maculata* OERSTED. a, Anterior end with everted pro-
boscis. ×10; b, 15th parapodium. ×40; c, 35th parapodium. ×40; d, 50th
parapodium. ×40; e, Right principal jaw. ×65; f, Jaw from ventral interval
between principal jaws. ×65; g, Jaw from dorsal interval between principal
jaws. ×300; h, V-shaped paragnathi from proboscis. ×65; i, Heart-shaped
papilla. ×300.

Hemipodus borealis JOHNSON

(Fig. 9)

Hemipodus borealis: JOHNSON, 1901, p. 411, pl. 10, figs. 104, 104 a.
Hemipodus yenourensis: IZUKA, 1912, p. 250, pl. 23, figs. 14–15.

Occurrence: Ishihama. Sp. No. H. 119.

Six specimens were examined. They were 70–110 mm in length. The
head is conical, slender, with 4 rather long tentacles. The annulation of
the prostomium in these specimens is not distinct, though IZUKA gives
15 annuli for the species. The papillae of the proboscis are slender,
rod-like. The jaw-support is elongated cylindrical in shape. The para-
podium is uniramous throughout the body. In the anterior parapodia
the dorsal and ventral cirri are subequal in length. The anterior ligule

of the parapodium can be subdivided into a broad proximal and a lanceolate slender distal portion as described by IzUKA, and the posterior ligule
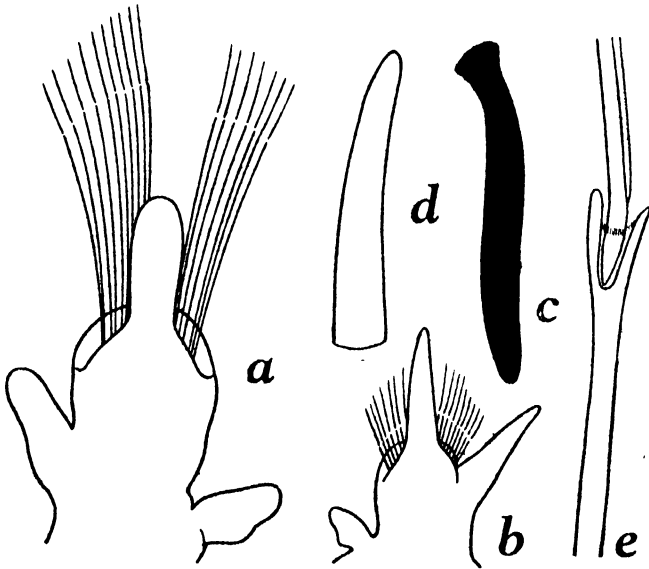
Fig. 9. *Hemipodus borealis* JOHNSON. a, 50th parapodium. ×65; b, Parapodium from posterior body. ×65; c, Jaw-support. ×120; d, Papilla from proboscis. ×500; e, A portion of seta. ×500.

is rounded, half-moon shaped, extending a little beyond the proximal part of the anterior ligule. The terminal lanceolate portion is subequal in length, with a ventral cirrus. In the middle part of the body the parapodium is well developed. The terminal elongated portion of the anterior ligule is longer than the ventral cirrus. At the lower margin of the dorsal cirrus there occurs a knob-like protuberance such as is shown in *H. roseus* or *H. patagonicus*. This protuberance exists in the posterior segments though it becomes gradually indistinct. In the posterior part of the body the rod-like distal portion of the anterior ligule and the ventral cirri are exceedingly elongated; the former being slightly shorter than the latter. The ventral cirri are slender, finger-shaped, and are about 4 times the length of the dorsal cirri. There are two small anal cirri.

Remarks: In general the present specimens agree well with *H. borealis* described by JOHNSON (1901), which is also closely allied to *H. yenourensis* recorded by IzUKA (1912), and it is difficult to separate these two species. As regards the variation of the parapodium in the

anterior and posterior parts of the body and the occurrence of the protuberance of the dorsal cirri both IZUKA and JOHNSON make no mention.

Family Eunicidae
Marphysa sanguinea MONTAGU

FAUVEL, 1936, p. 69; OKUDA, 1937, p. 286, fig. 31.

Occurrence: Konorihama; Takoshima. Sp. No. H. 71; 1257.

Ten specimens, of which the largest one measures 19 cm by 5.5 mm. The branchiae begin to appear from the 29th or 30th segments. The smallest specimen measuring 12 cm has the first branchia on the 23rd segment.

Onuphis conchylega SARS

IZUKA, 1912, p. 98, pl. 11, figs. 5-6; TAKAHASHI, 1938, p. 204, fig. 4.

Occurrence: Oisosaki; Koshiki-Ne. Collected by dredging. Sp. No. H. 84; 694.

Many tubes were collected. They are composed of agglutinated fragments of shells and pebbles.

Diopara neapolitana DELLE CHIAJE

Diopatra sugokai: IZUKA, 1912, p. 110, pl. 1, fig. 6, pl, 11, figs. 13-16.

Occurrence: Koyatori; Takoshima. Sp. No. H. 145; H. 147.

Lumbriconereis latreilli AUDOUIN et M. EDWARDS

Lumbriconereis japonica: IZUKA, 1912, p. 139, pl. 14, figs. 17-18.

Occurrence: Takoshima: Sp. No. H. 100; H. 133.

Capillary setae and compound hooks are found in anterior parapodia. From the 42nd setigerous segment backwards there are only hooks.

Arabella iricolor (MONTAGU)

FAUVEL, 1936, p. 70.

Occurrence: Yataroshima; Miyaga-Saki. Sp. No. H. 74; H. 115.

Two anterior body fragments. There are no distinct dark blue bands which are often seen in the species.

Arabella geniculata (CLAPAREDE) var. japonica, n. var.
(Fig. 10)

Occurrence: Takoshima. Collected by dredging. Sp. No. H. 103.

A single specimen divided into anterior and posterior body fragments. The body is slender. The prostomium is bluntly cone-shaped. There are 4 eyes, of which the anterior two are distinct and the other two situated further back are more or less obscure. The ventral surface of the prostomium is marked with two longitudinal arch-shaped bands. The area marked with these two bands is somewhat elevated. The first two segments are achaetous. The first segment is about half as long as the second on the dorsal side. The parapodium is of the usual shape, with a low rounded anterior lip and a sub-cylindrical posterior lip. The mammiliform dorsal cirri are present throughout the body even in the posterior body. The setae are limbate, capillary. Inferior to the acicular spine there are two or three bilimbate capillary setae, the borders of which are finely serrated. Superior to the spine there are a small number of the capillary setae distinctly bent and broadly bordered near the geniculated portion, of which the outer border
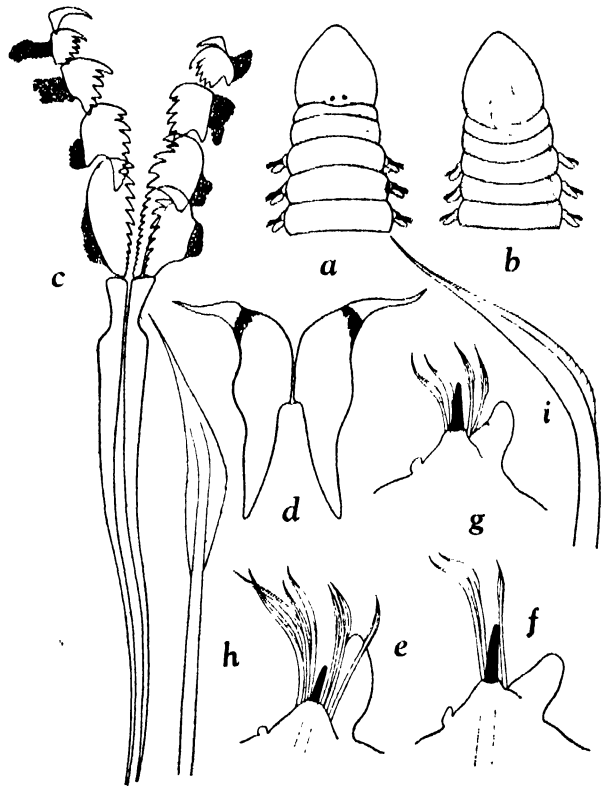
Fig. 10. *Arabella geniculata* (CLAPARÈDE) var. *japonica,* n. var. a, Anterior end. ×30; b, Anterior end, ventral view. ×30; c, Upper jaws. ×30; d, Lower jaw-plates. ×60; e, 10th parapodium. ×60; f, 90th parapodium. ×60; g, Parapodium from posterior body. ×60; h, Seta situated inferior to aciculum. ×370; i, Seta situated superior to aciculum. ×370.

bears about 6 teeth.   All of the parapodium are supported ·by a single
yellow acicular spine.   The upper jaws have a pair of long slender black
carriers.   There are no accessory supports.   M. I. and M. II are asym-
metrical.   The number of the teeth is as follows: M. I, 13+10; M. II,
9+18; M. III, 6+6; M. V, 1+1.   The lower jaws are black, more or
less bulged in the middle region.   The terminal portion of the lower
jaws is fringed with fin-like lamellaè.

Remarks: This variety may be classified in the group provided with
the upper jaw, in which the first pair is devoid of a special terminal
hamulus which is distinctly differentiated from the dental portion as is
shown in *A. geniculata* and *A. obscura*.   The new variety is, in general,
closely allied to the type, but can be easily distinguished by the occurrence
of a single acicular spine in the parapodium and by the multiple denticu-
lations in the upper jaw.   Usually species of the genus have three or
four rather slender, tapering acicular spines.

The following descriptions on the sedentary polychaetes are based
upon the materials which were provided for me after the previous paper
for the sedentary polychaetes from the same locality had been published.
Of 11 species added newly to the local fauna only one has been first
recorded from Japan.

Family Ariciidae
Haploscoloplos kerguelensis (McIntosh)

OKUDA, 1937, p. 103, figs. 5–6.

Occurrence: Kiriga-Saki.   Sp. No. H. 128.

A single anterior body fragment.   The thoracic segments are entirely
free from hooks.   The branchiae appear first on the 15th chaetiger.

Family Cirratulidae
Chaetozone spinosa MOORE
(Fig. 11)

MOORÉ, 1903, p. 468, pl. 26, figs. 73–74.

Occurrence: Yokoura.   Collected by dredging.   Sp. No. 1240 a.

A single complete specimen measures 45 mm for 123 setigerous seg-
ments.   The prostomium recalls that of Opheliid worms.   There are no
eyes and no sensory pits.   At the base of the head there is a pair of

scars of palpi, which are oblong, about two times as broad as those of the branchiae. The posterior stout hooks appear first in about the 70th segment.
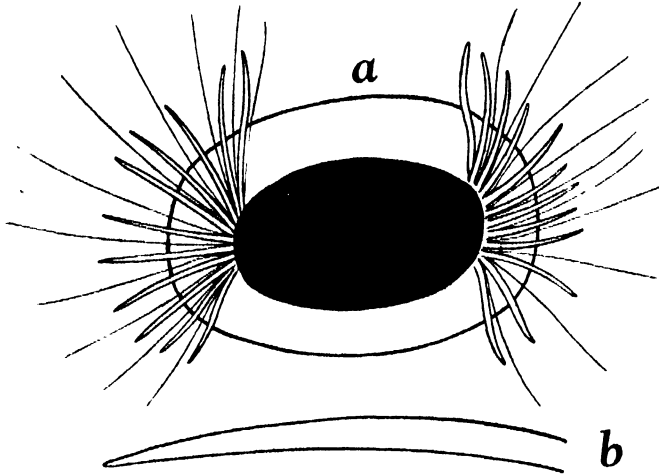
Fig. 11. *Chaetozone spinosa* MOORE. a, Dissected posterior segment, showing the distribution of hooks. ×30; b, Hook. ×180.

Family Maldanidae
Asychis gotoi (IZUKA)

Maldane gotoi: IZUKA, 1902, p. 109, pl. 3, figs. 1–8.
Maldane coronata: MOORE, 1903, p. 483, pl. 27, figs. 94–96.
Asychis gotoi: FAUVEL, 1934, p. 57, figs. 2–3; OKUDA, 1988, p. 100.

Occurrence: Okati Bay; Myozin-maé. Sp. No. 1562; H. 85.

Three specimens involved in muddy tubes were examined. The species is characterized by an anal plate which has several slender cirri and a cephalic plate with a denticulated rim. MOORE previously recorded the species from North Japan.

Maldane sarsi MALMGREN

ARWIDSSON, 1906, p. 251, pl. 6, figs. 192–199, pl. 10, figs. 333–338.

Occurrence: Oura Inlet. Collected by dredging. Sp. No. 1589 a.

Two specimens, the larger one measuring 62 mm. 19 setigerous segments. The first chaetiger is devoid of uncinigerous tori. The cephalic border is divided into three sections by a pair of shallow lateral incisions. The nuchal organs are short, divergent. The anal plate is rounded with

a border laterally incised. The ventral section of the border is slightly crenated. Only the anterior several segments are pigmented. The characteristics as mentioned by MOORE as to Japanese specimens were not found in the present specimens. The muddy tubes are partly very thick.

Family Owenidae
Owenia fusiformis DELLE CHIAJE

OKUDA, 1937, p. 252, fig. 27.

Occurrence: Yokoura. Collected by dredging. Sp. No. 1240 c.

Family Terebellidae
Amphitrite edwardsi (QUATREFAGES)
(Fig. 12)

FAUVEL, 1927, p. 245, fig. 84, a–i.
Amphitrite ramosissima: OKUDA, 1937, p. 57, fig. 6 (non MARENZELLER).

Occurrence: Izushima. Sp. No. 1596.

A single specimen devoid of tentacles measures 116 mm. No eye-spots. There is a large lateral flap on each of the 2nd and 3rd segments and a small one on the 4th. Twelve ventral gland shields. The notopods begin on the 4th segment and occur in 17 pairs. The double rows of ventral uncini extend from the 7th to the 16th uncinigers. The uncini bear about 4–6 rows of teeth above the main fang. The dorsal seta has a distinct border and a denticulated apex. The nephridial papillae are situated from the 3rd to the 11th segments. Compared with the European specimens, the present form is rather small in size, only 100 mm or slightly more instead of 250 or 300 mm. The present species differs from the closely allied species, *Amphitrite affinis* and *A. ramosissima*, in number of the nephridial papillae. In the former report I wrongly identified the species derived from the same locality as *A. ramosissima*. *Amphitrite bifurcata* described by MOORE from Sendai Bay may be identical with the present species though he made no mention as
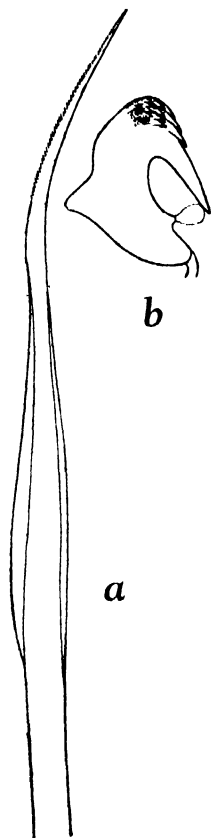
Fig. 12. *Amphitrite edwardsi* (QUATREFAGES). a, Dorsal seta with denticulated tip. ×150; b, Thoracic uncinus. ×260.

to the number of the nephridial papillae. The species has first recorded from Japan.

Family Sabellidae
Sabella aulanconota MARENZELLER
(Fig. 13)

MARENZELLER, 1884, p. 210, pl. 2, fig. 8; JOHANSSON, 1927, p. 124; FAUVEL, 1936. p. 84

Occurrence : Futamatazima. Sp. No. 1577 a.

A single complete specimen measures 68 mm excluding the branchiae which measure 24 mm. There are 33 branchial filaments on each side. There are no eyes or stylodes. There are 8 thoracic segments. The branchial lobes are more or less coiled in the ventral position. The collar is broadly separated at the dorsal surface and ends in small triangular lappets in the ventral median portion. Both the dorsal setae and the uncini correspond well with MARENZELLER's descriptions. The tube is tough, leather-like. The species seems to be widely distributed in Southern Japanese waters.
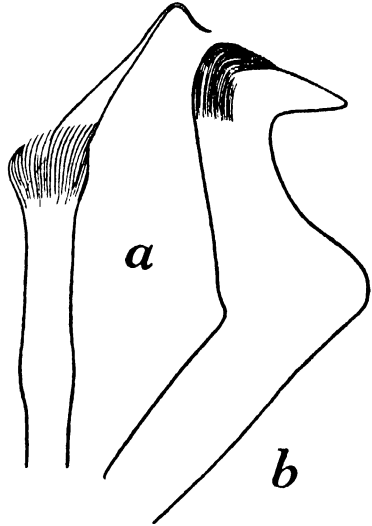
Fig. 13. *Sabella aulanconota* MARENZELLER. a, Pickaxe shaped seta. ×550; b, Avicular uncinus. ×350.

Sabella melanostigma SCHMARDA

JOHANSSON, 1927, p. 121.

Occurrence : Oura Inlet. Collected by dredging. Sp. No. 1545.

A single poorly-preserved specimen was identified with the species. The branchiae are 17 on each side. There are about 4 pairs of purple brown eye-spots on each branchial filament. The number of thoracic segments could not be detected. The uncini and the dorsal setae of thoracic segments were similar to those described by JOHANSSON, by whom the species was previously recorded from Japan.

Dasychone cingulata GRUBE

(Fig. 14)

WILLEY, 1905, p. 308, pl. 7, figs. 170-173; AUGENER, 1914, p. 122; FAUVEL, 1936, p. 85.

Occurrence: Onagawa Harbour. Collected by dredging. Sp. No. 1–42.

A single complete specimen measures 47 mm excluding branchiae which are 14 mm long. There are 94 setigerous segments. The body is light chocolate brown with many scattered reddish brown spots. The branchial filaments number about 30 in each fan. The dorsal stylodes of the branchiae are slender, rather filiform, attaining 21 or 22 pairs in the maximum number. As MOORE stated, the first dorsal stylode of each branchia is single and not paired as in the others, but I could not find any first stylode which is twice as long as and much thicker than any of the others, as the same author mentioned. The collar is rather low, being widely separated at the dorsal surface and terminates in broad triangular lappets in the ventral portion. There are 8 thoracic segments. The uncinus has a single tooth above a main fang. The capillary setae are limbate. *Dasychone japonica* recorded by McINTOSH seems to be only a variety of this widely distributed species, as AUGENER and WILLEY supposed.
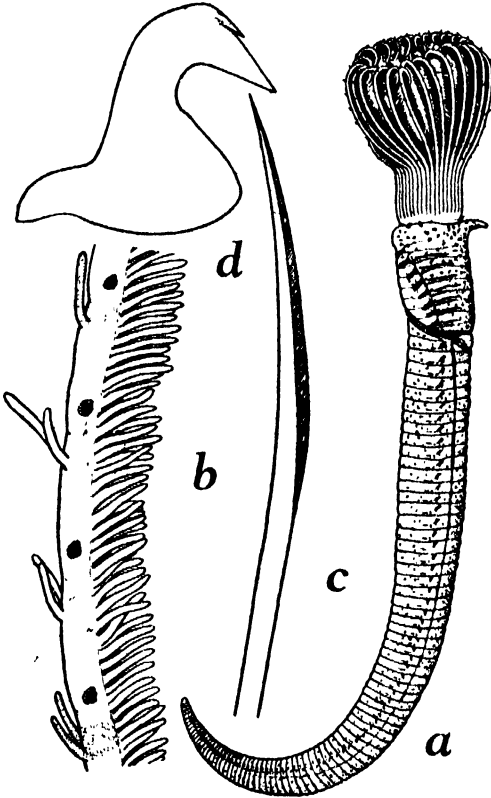
Fig. 14. *Dasychone cingulata* GRUBE. a, Entire body. ×2; b, A portion of a branchial filament. ×50; c, Dorsal thoracic seta. ×150; d, Thoracic uncinus. ×400.

Myxicola infundibulum (RENIER)

FAUVEL, 1936, p. 86.
Myxicola platychaeta: MARENZELLER, 1884, p. 213, pl. 3, fig. 6.

Occurrence: Mangoku-Ura. Attached to the oyster-bed. Sp. No. M-2.
A single complete specimen measures 35 mm.

Family Serpulidae

Hydroides ezoensis OKUDA

OKUDA, 1934, p. 239, figs. 5-7.

Occurrence: Konorihama. Sp. No. 1267 c; 1568 b.
Several tubes together with worms were collected.

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DIPLOIDISATION AND FRUIT-BODY FORMATION IN THE HYMENOMYCETES [1]

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(Received May 17, 1939)

INTRODUCTION

During the last two decades, our knowledge concerning the sexuality of the Hymenomycetes has been greatly increased by the investigations of BENSAUDE, KNIEP, BULLER, and others. In 1930 BULLER published his first report on the diploidisation of a haploid mycelium by a diploid mycelium. Since then this interesting subject has been studied by DICKSON, QUINTANILHA, and others. But the most important problems in connection with this phenomenon still remain unsolved. With regard to the fruit-body formation in the Hymenomycetes we have, among others, the papers of BREFELD, NEWTON, and BRUNSWIK. The information they contain is, however, far from satisfactory. So with the view of throwing further light on the mechanism of the diploidisation, and on the fruit-body formation in the Hymenomycetes, the following experiments were made in Sendai, from 1931 onwards.

In the first place, three mutually compatible haploid mycelia, which had been derived from two different geographical strains, were inoculated together on the same culture medium in a small flask, and the constitution of the sex-factors of the resulting fruit-bodies was analysed. Next a haploid mycelium was diploidised by a diploid mycelium, the two nuclei of which are compatible with that of the haploid mycelium, and the sexual constitution of the resulting fruit-bodies was analysed. By these means, it was possible to determine with great exactness the process of the diploidisation of a haploid mycelium by a diploid mycelium, and also the process of fruit-body formation.

MATERIALS AND METHODS

MATERIALS: In the following experiments, two species of the Hymenomycetes, namely *Stropharia semiglobata* (BATSCH) FR. and *Galera*

tenera (SCHAEFF.) FR. were used.   For the identification of these species I am greatly indebted to Dr. S. KAWAMURA, Professor of Chiba Horti-cultural College, and my most sincere thanks are due to him.   The former species, *S. semiglobata*, was shown in 1931 by the present writer to be a bipolar fungus.   The latter species, *G. tenera*, is demonstrated in the present investigation to be a tetrapolar fungus, and several geographical strains are also found in this species.   Combinations of the two compatible haploid mycelia of each species always produce normal fruit-bodies, and the segregation of sex-factors in the fruit-body is mendelian and normal.

METHODS :   In order to study the process of diploidisation of a haploid mycelium by a diploid mycelium, and also the process of the fruit-body formation, the following methods were devised.

A) *Culture of the fruit-body.*   At the bottom of a small flask, horse-dung was laid evenly, and a small quantity of water was added to prevent desiccation.   The flask was then plugged with cotton-wool, and was sterilized for 1 to 2 hours at the temperature of 120°C. in an autoclave. Inoculations were made in the following two different manners and the resulting fruit-bodies were examined.   In the cultures of the fruit-bodies, care was taken to have only one fruit-body in a culture.   When two or more fruit-bodies appeared, the ones that were superfluous were removed from the culture, while they were still unripe, in order to avoid contami-nation.

1) The three-inocula method : — Three healthy and mutually comptible haploid mycelia of known sexual constitution (for example, haploid mycelia, A_1, A_2, A_3, of the bipolar species) were inoculated together in the flask containing the sterilized horse-dung, and the positions of the inoculated spots on the culture medium were marked on the wall of the flask. After a few days, cultures in which all three mycelia grew equally well were allowed to fruit.

2) The single-inoculum method : — A haploid mycelium (for example, A_8 of the bipolar species) was allowed to grow on dung-agar contained in a Petri-dish for a few days, and was then inoculated at its periphery with a tiny diploid mycelium (for example, $A_5 + A_6$ of the same species). A few days after the inoculation, the large haploid mycelium became diploidised by the diploid mycelium ; clamp-connections appeared on all its peripheral hyphae.   The hyphae of the central portion, however, did not at first generally show any sign of clamp-connection.   But when culture becomes old, clamp-connections are found abundantly in the central

portion, most probably in the newly grown mycecilia of this portion. Generally one or two, but sometimes a larger number of inocula were taken from this diploidised mycelium and were inoculated separately, one in each flask containing the sterilized horse-dung.

B) *Isolation of haploid mycelia.* The spores of the fruit-bodies, reared by the two above mentioned methods, were removed from as many different places as possible, directly from their hymeniums, or indirectly from their spore-deposits, by means of a sterilized platin loop. These spores were diluted with sterilized water, and a small quantity of this solution was added to the melted dung-agar, and was poured into a sterilized Petri-dish.

After 1 or 2 days, isolated mycelia were transferred, one by one, with a piece of agar to a sterilized glass-slide, by means of a flattened platin loop, and were examined under the microscope in order to discover whether they contained one spore only. The mycelia which were definitely ascertained to be monosporous were then transferred to separate test-tubes containing sterilized horse-dung-agar-slopes, and were kept at a temperature of about 25°C. in an incubator.

The sexual constitution of the mycelia thus isolated was determined by pairing them with the tester mycelia of known sexual constitution.

EXPERIMENTS AND RESULTS

A) *Studies of the fruit-body formation by the "three-inocula method".* The following two experiments were made.

1) The haploid mycelia derived from the spores of the two wild fruit-bodies, A_1A_2 and A_3A_4, of *Stropharia semiglobata*, a bipolar species, were employed. In some experiments, instead of using only three, all the four haploid mycelia were inoculated on the same culture medium. The results of the experiments are indicated in TABLE 1.

2) The haploid mycelia derived from the spores of the two wild fruit-bodies, $A_1A_2B_1B_2$ and $A_3A_4B_3B_4$, of *Galera tenera*, a tetrapolar species, were employed. In some experiments, instead of three haploid mycelia, a diploid mycelium together with a haploid mycelium were employed. The results of the experiments are indicated in TABLE 2.

It is seen from TABLE 1 that a fruit-body producing spores of more than two kinds was never yielded. It is also seen from TABLE 2 that a fruit-body producing spores of more than four kinds was never yielded. So, we may conclude that the fruit-bodies produced in the experiments are built up of only one kind of diploid mycelium.

TABLE 1

Experiments by three- or four-inocula method in Stropharia seiniglobata

The circle in the third column indicates the bottom of a culture-flask. The inoculated position and the sex of haploid mycelia are shown by A_1, A_2, A_3, etc. The black dot in the circle denotes the position of the analysed fruit-body.

No.	Combination of inocula	Diagrams showing the relation between inocula and the analysed fruit-body	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
34	A_1 A_2 A_3		A_1 A_2	11 6	A_1 A_2
11	A_1 A_2 A_4		A_1 A_4	13 4	A_1 A_4
48	A_1 A_3 A_4		A_1 A_3	16 16	A_1 A_3
9	A_1 A_3 A_4		A_1 A_4	5 2	A_1 A_4
14	A_1 A_2 A_3 A_4		A_1 A_3	8 10	A_1 A_3
31	A_1 A_2 A_3 A_4		A_1 A_3	6 11	A_1 A_3

No.	Combination of inocula	Diagrams showing the relation between inocula and the analysed fruit-body	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
16	A_1 A_2 A_3 A_4		A_1 A_3	3 3	A_1 A_3
32	A_1 A_2 A_3 A_4		A_1 A_3	12 15	A_1 A_3
39	A_1 A_2 A_3 A_4		A_1 A_3	9 11	A_1 A_3
28	A_1 A_2 A_3 A_4		A_1 A_3	12 10	A_1 A_3

TABLE 2

Experiments in Galera tenera

The signs used in TABLE 2 are the same in TABLE 1.

No.	Combination of inocula	Diagrams showing the relation between inocula and the analysed fruit-body	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
327	A_1B_1 A_2B_2 A_3B_3		A_1B_1 A_3B_3 A_1B_3 A_3B_1	4 5 4 1	A_1B_1 A_3B_3

No.	Combination of inocula	Diagrams showing the relation between inocula and the analysed fruit-body	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
333	A_1B_1 A_2B_2 A_3B_3	(diagram)	A_1B_1 A_3B_3 A_1B_3 A_3B_1	5 8 7	A_1B_1 A_3B_3
228	A_1B_1 A_2B_2 A_3B_3	(diagram)	A_1B_1 A_3B_3 A_1B_3 A_3B_1	4 4 5	A_1B_1 A_3B_3
332	A_1B_1 A_2B_2 A_3B_3	(diagram)	A_2B_2 A_3B_3 A_2B_3 A_3B_2	6 4 1 2	A_2B_2 A_3B_3
326	A_1B_1 A_2B_2 A_3B_3	(diagram)	A_2B_2 A_3B_3 A_2B_3 A_3B_2	6 4 6	A_2B_2 A_3B_3
336	A_1B_1 A_2B_2 A_3B_4	(diagram)	A_1B_1 A_3B_4 A_1B_4 A_3B_1	3 5 11	A_1B_1 A_3B_4
339	A_1B_1 A_2B_2 A_3B_4	(diagram)	A_1B_1 A_3B_4 A_1B_4 A_3B_1	1 5 4	A_1B_1 A_3B_4
231	A_1B_1 A_2B_2 A_4B_3	(diagram)	A_2B_2 A_4B_3 A_2B_3 A_4B_2	6 3 7 7	A_2B_2 A_4B_3

No.	Combination of inocula	Diagrams showing the relation between inocula and the analysed fruit-body	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
337	A_1B_2 A_2B_1 A_3B_4		A_2B_1 A_3B_4 $\left.\begin{array}{l}A_2B_4\\A_3B_1\end{array}\right\}$	4 3 11	A_2B_1 A_3B_4
330	A_1B_2 A_3B_4 A_4B_3		A_1B_2 A_3B_4 A_1B_4 A_3B_2	0 1 4 1	A_1B_2 A_3B_4
331	A_1B_2 A_3B_4 + A_4B_3		A_1B_2 A_4B_3 $\left.\begin{array}{l}A_1B_3\\A_4B_2\end{array}\right\}$	6 3 10	A_1B_2 A_4B_3
338	A_1B_2 A_3B_4 + A_4B_3		A_1B_2 A_4B_3 $\left.\begin{array}{l}A_1B_3\\A_4B_2\end{array}\right\}$	2 3 4	A_1B_2 A_4B_3

B) Studies of BULLER's Phenomenon.

BULLER studied the diploidisation process among the mycelia derived from a single fruit-body of a *Coprinus lagopus*. The present writer studied this phenomenon by employing the geographical strains of a tetrapolar species, *Galera tenera*. In the first place, the constitution of the two wild fruit-bodies of this fungus, $A_1A_2B_1B_2$ and $A_3A_4B_3B_4$ were determined by pairing experiments. Then the diploidisation-experiments of 100 different combinations were made. Some of them are shown in TABLE 3 and 4.

As is shown in these tables, diploidisation occurred in all these combinations. The results may be summarised as follows.

TABLE 3

*Diploidisation of mycelia derived from a single frui·-body
of Galera tenera*

Type	Large haploid mycelium	Small inoculum	Growth of large haploid mycelium		Approximate speed of diploidisation	
			Days	Radius mm.	Days	Distance mm.
a	A_1B_1	A_2B_2	10	25	4	58
	A_2B_2	A_1B_1	10	24	4	61
	A_1B_2	A_2B_1	10	18	4	46
	A_2B_1	A_1B_2	10	23	4	56
b	A_1B_1	$A_1B_1+A_2B_2$	10	24	4	46
	A_2B_2	$A_2B_2+A_1B_1$	10	23	4	58
	A_1B_2	$A_1B_2+A_2B_1$	10	19	4	49
	A_2B_1	$A_2B_1+A_1B_2$	10	24	4	61
c	A_1B_1	$A_1B_2+A_2B_1$	·10	29	7	47
	A_2B_2	$A_1B_2+A_2B_1$	10	24	7	60
	A_1B_2	$A_1B_1+A_2B_2$	10	24	7	*
	A_2B_1	$A_1B_1+A_2B_2$	10	23	7	56

* Not measured.

TABLE 4

*Diploidisation of mycelia derived from two different fruit-bodies
of Galera tenera*

Type	Large haploid mycelium	Small inoculum	Growth of large haploid mycelium		Approximate speed of diploidisation	
			Days	Radius mm.	Days	Distance mm.
a′	A_1B_1	A_4B_4	10	24	4	63
	A_2B_2	A_4B_4	10	23	4	55
	A_1B_2	A_4B_4	10	17	4	46
	A_2B_1	A_4B_4	10	23	4	55
b′	A_1B_1	$A_1B_1+A_4B_4$	6	16	4	50
	A_2B_2	$A_2B_2+A_4B_4$	6	17	4	53
	A_1B_2	$A_1B_2+A_4B_4$	6	14	4	47
	A_2B_1	$A_2B_1+A_4B_4$	6	16	4	50
c′	A_1B_1	$A_3B_3+A_4B_4$	10	24	4	50
	A_2B_2	$A_3B_3+A_4B_4$	10	22	4	58
	A_1B_2	$A_3B_3+A_4B_4$	10	18	4	46
	A_2B_1	$A_3B_3+A_4B_4$	10	23	4	57

(1) Large haploid   Small inocula
    a. A_1B_1 × A_2B_2
    b. A_1B_1 × $(A_1B_1 + A_2B_2)$
    c. A_1B_1 × $(A_1B_2 + A_2B_1)$
(2) Large haploid   Small inocula
    a'. A_1B_1 × A_1B_1
    b'. A_1B_1 × $(A_1B_2 + A_1B_1)$
    c'. A_1B_1 × $(A_3B_3 + A_4B_1)$

The cases in group (1) are the same as those of BULLER's experiments in *Coprinus lagopus*, while those of group (2) can be realised only when we combine the mycelia of different geographical strains. Type c' is specially interesting, because it is the diploidisation of a large haploid mycelium by a small diploid inoculum containing two nuclei, which are both compatible with that of the large mycelium. In this combination, the diploidisation progressed very smoothly, while in the illegitimate combination (1) c, it progressed very slowly and patchily. From the experiments (1) b, c, and (2) b', c', we may conclude that, in *Galera tenera*, any diploid mycelium is able to diploidise a haploid one. The same results were obtained also in *Stropharia semiglobata*, the details of which are omitted here for the sake of brevity.

C) *Studies of the fruit-body formation by means of BULLER's pheno-menon.*
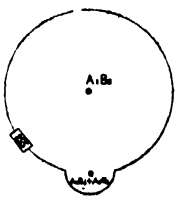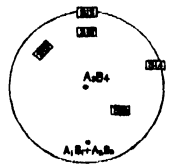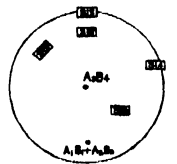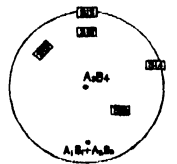
As before mentioned, we can diploidise a large haploid mycelium by a small diploid inoculum, the two nuclei of which are both compatible with that of the haploid mycelium. Then it is interesting to discover what sexual constitution the resulting fruit-body would have, for the information on this point might explain, not only the process of the diploidisation by a diploid mycelium, but also the process of the fruit-body formation. So the following two experiments were made.

1) For this experiment, mycelia derived from two wild fruit-body $A_1A_2B_1B_2$ and $A_3A_4B_3B_4$ of *Galera tenera* were employed. TABLE 5.

2) For this experiment, mycelia derived from two wild fruit-bodies A_5A_6 and A_7A_8 of *Stropharia semiglobata* were employed. TABLE 6.

It is seen from TABLE 5 that one fruit-body of each culture segregated only four kinds of haploid mycelia, and never more than four; and from TABLE 6 that one fruit-body of each culture segregated only two kinds of haploid mycelia, and never more than two. So, from the results of these experiments, it may be concluded that a fruit-body is constituted

TABLE 5

The diploidisation and the fruit-body formation in Galera tenera

No.	Combinations		Diagrams showing the positions of the agar-pieces which were cultured	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
	Large haploid mycelium	Small diploid inoculum				
255	A_1B_2	A_3B_4 + A_4B_3		A_1B_2 A_4B_3 A_1B_3 A_4B_2	2 4 } 3	A_1B_2 A_4B_3
312	A_3B_4	A_1B_1 + A_2B_2		A_3B_4 A_2B_2 A_3B_2 A_2B_4	2 3 3 4	A_3B_4 A_2B_2
314	A_3B_4	A_1B_1 + A_2B_2		A_3B_4 A_2B_2 A_3B_2 A_2B_4	6 3 1 6	A_3B_4 A_2B_2
318	A_3B_4	A_1B_1 + A_2B_2		A_3B_4 A_2B_2 A_3B_2 A_2B_4	1 3 1 1	A_3B_4 A_2B_2
319	A_3B_4	A_1B_1 + A_2B_2		A_3B_4 A_2B_2 A_3B_2 A_2B_4	2 1 } 9	A_3B_4 A_2B_2
320	A_3B_4	A_1B_1 + A_2B_2		A_3B_4 A_2B_2 A_3B_2 A_2B_4	8 9 1 6	A_3B_4 A_2B_2
315	A_3B_4	A_1B_2 + A_2B_1		A_3B_4 A_1B_2 A_3B_2 A_1B_4	5 8 3 10	A_3B_4 A_1B_2

No.	Combinations		Diagrams showing the positions of the agar-pieces which were cultured	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
	Large haploid mycelium	Small diploid inoculum				
249	A_4B_3	A_1B_2 + A_2B_1		A_4B_3 A_1B_2 A_4B_2 A_1B_3	3 1 1 4	A_4B_3 A_1B_2
250	A_4B_3	A_1B_2 + A_2B_1		A_4B_3 A_2B_1 A_4B_1 A_2B_3	7 1 1 1	A_4B_3 A_2B_1

TABLE 6

The diploidisation and the fruit-body formation in *Stropharia semiglobata*

No.	Combinations		Diagrams showing the positions of the agar-pieces which were cultured	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
	Large haploid mycelium	Small diploid inoculum				
18	A_5	A_7 + A_8		A_5 A_7	14 8	A_5 A_7
20	A_5	A_7 + A_8		A_5 A_8	5 6	A_5 A_8
24	A_5	A_7 + A_8		A_5 A_7	4 6	A_5 A_7
25	A_5	A_7 + A_8		A_5 A_7	3 7	A_5 A_7
37	A_6	A_7 + A_8		A_6 A_7	6 4	A_6 A_7
38	A_6	A_7 + A_8		A_6 A_7	9 7	A_6 A_7

No.	Combinations		Diagrams showing the positions of the agar-pieces which were cultured	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
	Large haploid mycelium	Small diploid inoculum				
43	A_7	A_5 + A_6		A_7 A_5	4 6	A_7 A_5
44	A_7	A_5 + A_6		A_7 A_5	4 6	A_7 A_5
45	A_7	A_5 + A_6		A_7 A_5	6 5	A_7 A_5
47	A_7	A_5 + A_6		A_7 A_5	10 6	A_7 A_5
48	A_7	A_5 + A_6		A_7 A_5	4 5	A_7 A_5
49	A_7	A_5 + A_6		A_7 A_5	3 7	A_7 A_5
27	A_8	A_5 + A_6		A_8 A_6	6 5	A_8 A_6
28	A_8	A_5 + A_6		A_8 A_5	9 7	A_8 A_5
30	A_8	A_5 + A_6		A_8 A_5	3 9	A_8 A_5
31	A_8	A_5 + A_6		A_6 A_5	6 4	A_8 A_5
32	A_8	A_5 + A_6		A_8 A_5	4 5	A_8 A_5
34	A_8	A_5 + A_6		A_8 A_5	6 3	A_8 A_5
35	A_8	A_5 + A_6		A_8 A_5	2 7	A_8 A_5

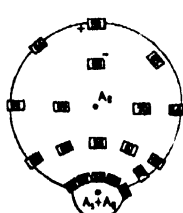| No. | Combinations | | Diagrams showing the positions of the agar-pieces which were cultured | Sexes and Nos. of segregants from a single fruit-body | | Constitution of the fruit-body |
	Large haploid mycelium	Small diploid inoculum				
51	A_8	A_5 + A_6		A_8 A_5	13 9	A_8 A_5
52	A_8	A_5 + A_6		A_8 A_5	8 3	A_8 A_5
53	A_8	A_5 + A_6		A_8 A_5	3 6	A_8 A_5
54	A_6	A_5 + A_6		A_8 A_5	6 7	A_8 A_5
55	A_8	A_5 + A_6		A_8 A_5	7 13	A_8 A_5
56	A_8	A_5 + A_6		A_8 A_5	6 6	A_8 A_5
57	A_8	A_5 + A_6		A_5 A_6	7 11	A_5 A_6
58	A_8	A_5 + A_6		A_8 A_5	11 8	A_8 A_5
59	A_8	A_5 + A_6		A_5 A_6	10 9	A_5 A_6
60	A_8	A_5 + A_6		A_8 A_5	6 6	A_8 A_5
61	A_8	A_5 + A_6		A_8 A_5	7 4	A_8 A_5
62	A_8	A_5 + A_6		A_8 A_5	6 4	A_8 A_5
63	A_8	A_5 + A_6		A_8 A_5	4 6	A_8 A_5
64	A_8	A_5 + A_6		A_8 A_5	3 8	A_8 A_5

No.	Combinations		Diagrams showing the positions of the agar-pieces which were cultured	Sexes and Nos. of segregants from a single fruit-body		Constitution of the fruit-body
	Large haploid mycelium	Small diploid inoculum				
65	A_8	A_5 + A_6		A_8	9	A_8
				A_6	4	A_5
67	A_8	A_5 + A_6		A_8	3	A_8
				A_5	6	A_5
68	A_8	A_5 + A_6		A_8	5	A_8
				A_5	6	A_5
69	A_8	A_5 + A_6		A_8	4	A_8
				A_5	6	A_5
70	A_8	A_5 + A_6		A_8	8	A_8
				A_5	4	A_5

of only one kind of diploid mycelium.

In the above experiments, the fruit-bodies reared from the diploidised mycelia which were taken from the same Petri-dish were in most cases of the same constitution, though in a few cases they were of different constitutions e. g. TABLE 5, No. 249, 250.

DISCUSSIONS

In most cases of our experiments concerning the diploidisation of a large haploid mycelium by a small diploid inoculum, only one kind of fruit-body was yielded. We have, however, on a few occasions secured two kinds of fruit-bodies from the same culture in a Petri-dish. For example, in the legitimate combination $A_4B_3 \times (A_1B_2 + A_2B_1)$, we have secured two kinds of fruit-bodies, $A_4A_1B_3B_2$ and $A_4A_2B_3B_1$, from the same culture. From the latter case it is concluded that, in a legitimate combination, two kinds of nuclei of a diploid inoculum may migrate into a large haploid mycelium. In 1931 BULLER also obtained a fruit-body in an illegitimate combination. Based upon this result RAWITSCHER (1933) propounded the theory that, in an illegitimate combination, two kinds of nuclei of a diploid inoculum may migrate into a large haploid.

In a legitimate combination, the rather rare occurrence of two kinds of fruit-bodies are explicable from the assumption that one of the two nuclei of a diploid inoculum divides more frequently in the large haploid mycelium than the other does.

Very slow diploidisation of a large haploid mycelium in an illegitimate combination can also be explained by the same assumption.

The possibility of the participation of two or more kinds of diploid mycelia in the formation of a single fruit-body should be absolutely rejected as a result of the experiments made in the present research. The hyphal purity of a single fruit-body may in all possibility be due to the fact that a fruit-body originate from a single cell of a diploid mycelium. (BREFELD, 1877., NEWTON, 1926.)

SUMMARY

1) Geographical strains of a bipolar fungus, *Stropharia semiglobata* (BATSCH) FR. and of a tetrapolor fungus, *Galera tenera* (SCHAEFF.) FR. were used as materials.

2) A large haploid mycelium of these fungi was mated with a small diploid mycelium of the same species in legitimate and illegitimate combinations, and it was ascertained that diploidisation occurred in each cases. From these researches, it is concluded that a diploid mycelium of any kind is able to diploidise any haploid mycelium of the same species.

3) A large haploid mycelium diploidised by a small diploid mycelium, the two nuclei of which are both compatible with the nucleus of haploid mycelium, produced, in a few cases, fruit-bodies of two different constitutions. Thus it may be concluded that the nuclei of two kinds out of a diploid mycelium may migrate into a large haploid mycelium.

4) Three mutually compatible haploid mycelia were inoculated on the same culture medium in a small flask. Or a piece of a large halploid mycelium, after its diploidisation by a diploid mycelium, the two nuclei of which are both compatible with the nucleus of the haploid mycelium, was transferred to a culture medium. The sexual constitutions of the fruit-bodies grown in these cultures were analysed. In every case we obtained exclusively normal fruit-bodies consisting of only one diploid mycelium : two kinds of haploid mycelia in the bipolar species, and four kinds in the tetrapolar species were segregated from a single fruit-body. From this we consider we are justified in concluding that a fruit-body originates perphaps from a single cell of a diploid mycelium.

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MACRURA AND ANOMURA OF DECAPOD CRUSTACEA
FOUND IN THE NEIGHBOURHOOD OF
ONAGAWA, MIYAGI-KEN

By

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(With 13 text-figures)
(Received March 30, 1939)

Recently, by the courtesy of Professor S. Hôzawa and of Lecturer T. Imai of the Tôhoku Imperial University, I have had an opportunity to examine the specimens of Macrura and Anomura collected in the neighbourhood of the Onagawa Oceano-chemical Institute of the same University, which is situated on the north-eastern coast of Honsyû, Japan.

The number of species contained in the collection is forty-five in all, of which twenty-five are Macrourous species and the remaining twenty are Anomourous. The species thus far obtained in this district are rather meagre in number, but they present some interesting features in respect to their distribution. Though the distribution of most of the subtropic species is limited to the south of Kinkazan, on the Pacific coast of Honsyû, many specimens of such species are found among collections from Onagawa where lies a little north of Kinkazan. This fact seems to be due to the current of the sea as I have already mentioned in my paper published in 1933. *Pandalopsis lamelligera* (Brandt) and *Upogebia isaeffi* (Balss) are species which have not hitherto been obtained from Japanese waters. On the other hand two species of shrimps and a hermit crab found here are new to science, i. e., *Spirontocaris onagawaensis*, *Nectocrangon hozawai* and *Eupagurus imaii*. *Spirontocaris minuta* Yokoya was originally described from immature specimens, but this time I have found some mature ones in the collection. *Latreutes dorsalis* Stimpson is one species which has, as far as I know, not been collected since it was originally described in 1860. The following are the species which are distributed, or are thought to be distributed, in the subtropic regions: *Trachypenaeus curvirostris* (Stimpson), *Ceratopenaeus dalei* (Rathbun), *Alpheus brevicristatus* de Haan, *Alpheus japonicus* Miers, *Alpheus haanii* Ortmann, *Spirontocaris geniculata* (Stimpson), *Spirontocaris rectirostris* (Stimpson), *Latreutes*

planirostris DE HAAN, *Crangon affinis* DE HAAN, *Callianassa petalura* STIMPSON, *Paguristes digitalis* STIMPSON, and *Eupagurus dubius* ORTMANN. The occurence of these species in this district is supposed to be due to the warm current, which first flows northwards in the Japan Sea along the west coast of Honsyû and then after passing though the Tugaru Strait, flows southward along the east coast of Honsyû together with the cold ocean current.

MACRURA

Penaeidae BATE

Genus TRACHYPENAEUS ALCOCK

Trachypenaeus curvirostris (STIMPSON)

Japanese name : Saru-ebi

Penaeus curvirostris STIMPSON, 1860, p. 44; KISHINOUYE, 1900, p. 23, pl. 6, fig. 4, pl. 7, fig. 10, 10 A–C; DE MAN, 1907, p. 436.
Parapenaeus curvirostris, RATHBUN, 1902, p. 38.
Trachypenaeus curvirostris, BALSS, 1914, p. 11; YOKOYA, 1930, p. 526; 1933, p. 9.

Loc. Okati Bay 14 m. deep. July 17, 1935. 1 female.

Konorihama, trap net. June 28, 1935. 3 females.

The specimens are nearly equal in length, one measuring 85 mm. in total length. The species is provided with a small but distinct supraorbital tooth as in the case of *T. asper* ALCOCK.

Distribution: Concerning the distribution of the present species I have stated in my previous paper published in 1933.

Genus CERATOPENAEUS KISHINOUYE

Ceratopenaeus dalei (RATHBUN)

Japanese name : Daru-ebi

Parapenaeus dalei RATHBUN, 1902, p. 42.
Ceratopenaeus dalei, YOKOYA, 1930, p. 526; 1933, p. 6.

Loc. Siranezaki, 34 m. deep. July 20, 1935. 3 females.

Yatarôzima, 34 m. deep. July 23, 1935. 1 female.

Distribution: Japan : On the Pacific side, it has not been reported from north of Kinkazan.

Pasiphaeidae BATE

Genus LEPTOCHELA STIMPSON

Leptochela gracilis STIMPSON

Japanese name : Hosohasami-ebi

STIMPSON, 1860, p. 42; BATE, 1888, p. 860, pl. 189, fig. 2; BALSS, 1914, p. 19; YOKOYA, 1933, p. 13.

Loc. Koyatori Inlet, 18 m. deep. July 19, 1935. 1 male.
Distribution : Corea ; Japan : Around Honsyû, Sikoku and Kyûsyû.

Pandalidae BATE

Genus PANDALUS LEACH

Pandalus nipponensis YOKOYA

Japanese name : Botan-ebi

YOKOYA, 1933, p. 16, text-fig. 5.

Loc. Kosikine, 19 m. deep. July 18, 1935. 2 females, one of which bears eggs.
Distribution : Pacific side of Honsyû ; it has not been recorded from north of Kinkazan.

Pandalus borealis KRÖYER

Japanese name : Akataraba-ebi

RATHBUN, 1904, p. 35; 1929, p. 8; YOKOYA, 1933, p. 25.

Loc. Off Ozaki, about 130 fathoms deep. December 23, 1935. 1 male.
Distribution : Circumpolar. From Greenland to Cape Cod ; from Bering Sea to the Columbia River ; northern Europe ; Japan Sea ; from the Pacific side of Japan, it has hitherto not been known.

Pandalus hypsinotus BRANDT

Japanese name : Toyama-ebi

BRANDT, 1851, p. 125; DOFLEIN, 1902, p. 635, pl. 4, figs. 1 & 2; RATHBUN, 1902, p. 46; BRASHNIKOW, 1907, p. 114, pl. 2, fig. 9; BALSS, 1914, p. 29; YOKOYA, 1933, p. 16.

Loc. Onagawa Harbour, 8 m. deep. August 2, 1935. 1 young specimen.
Distribution : Unalasca ; Bering Sea ; Japan : Hokkaidô and Japan Sea ; from the Pacific side of Honsyû it has not been reported.

Genus PANDALOPSIS BATE

Pandalopsis lamelligera (BRANDT)

Japanese name: Hiraasiaka-ebi

Pandalus lamelligerus BRANDT, 1851, p. 124, pl. 5, fig. 20.
Pandalopsis lamelligera, BRASHNIKOW, 1907, p. 99; BALSS, 1914, p. 32.

Loc. Konorihama, trap-net, December 15, 1934. 1 egg-bearing female.

The terminal halves of the rostrum and antennal scales were broken in the above specimen, but in other respects it is referable to the present species. This specimen is shown in Fig. 1.

Distribution: Okhotsk Sea. It has not been known from Japanese waters.
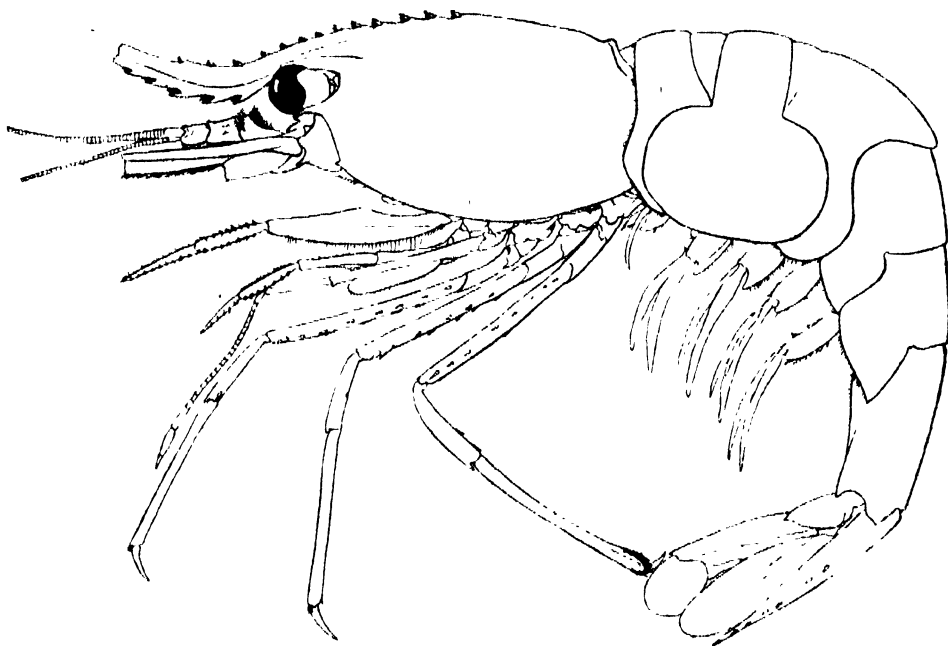
Fig. 1. *Pandalopsis lamelligera* (BRANDT). (Natural size)

Alpheidae BATE

Genus ALPHEUS FABRICIUS

Alpheus brevicristatus DE HAAN

Japanese name: Haziki-ebi

Alpheus malabaricus brevicristatus DE HAAN, 1850, p. 177, pl. 45, fig. 1.

A. malabaricus, ORTMANN, 1890, p. 481.

A. kingsleyi MIERS, 1879, p. 54.

Loc. Onagawa Harbour, 6 m. deep. July 16, 1935. 2 males and 2 females, one of the females bearing eggs.

An accessory appendix found on the margin of the second pleopod is noticeable in the male; this feature is shown in Figure 2 together with that of *Alpheus haanii* ORTMANN.
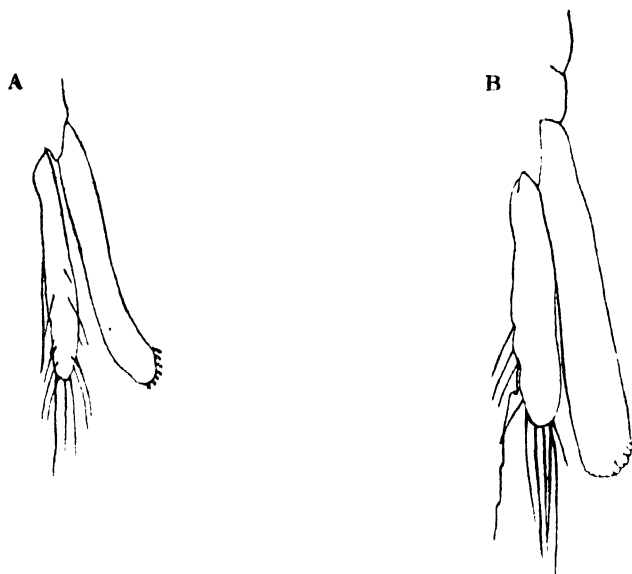
Fig. 2. Inner margin of endopodite of 2nd pleopod, showing accessory appendix.
A. *Alpheus brevicristatus* DE HAAN. B. *Alpheus haanii* ORTMANN.

Distribution: Japan: Tokyo Bay, Sagami Bay (ORTMANN); Toba, Mie-ken (MIERS). I have examined some numbers of specimens of this species taken from Naha, Loo Choo Isls. It was also obtained from southern Corea, Mikawa Bay and Misaki, Kanagawa-ken, etc. Thus this species seems to have subtropic distribution.

Alpheus japonicus MIERS

Japanese name: Tenagateppô-ebi

MIERS, 1879, p. 53; ORTMANN, 1890, p. 476, pl. 36, fig. 14; DE MAN, 1907, p. 430, pl. 33, fig. 53; YOKOYA, 1930, p. 527.

Loc. Onagawa Harbour, 8 m. deep. July 16, 1935. 3 egg-bearing females.

Distribution: Japan: Southern Japan; On the side of the Japan Sea,

it is distributed northwards to Mutu Bay, but on the Pacific side of Honsyû, it has not been reported from north of Tokyo Bay.

Alpheus haanii ORTMANN

Japanese name : Koteppô-ebi

Alpheus minor DE HAAN, 1849, p. 180, pl. 45, fig. 5.
Alpheus haanii ORTMANN, 1890, p. 472; DE MAN, 1897, p. 751.

Loc. Onagawa Harbour, 8 m. deep. August 2, 1935. 2 males and 10 egg-bearing females.

The length of the larger chela is individually variable compared with that of the carapace. In the larger male, which measures 41,8 mm. in total length, the larger chela is about twice as long as the carapace and about four times as wide as long.   While in the smaller male, which is 31,9 mm. long, the larger chela is one and a half times as long as the

A

B

C
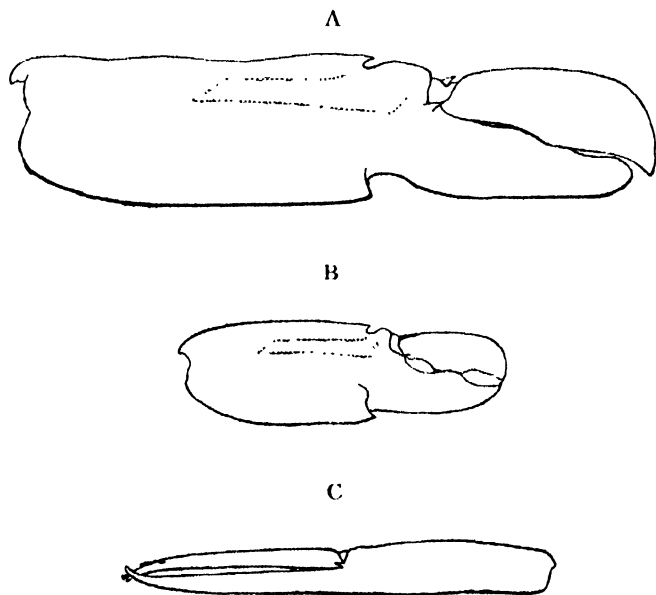
Fig. 3. *Alpheus haanii* ORTMANN.

A. Larger chela of a male, measuring 41,8 mm. in total body length, exterior aspect. (×3)
B. Larger chela of a male, measuring 31,9 mm. in total body length, exterior aspect. (×3)
C. Smaller chela of a female, measuring 44,2 mm. in total body length, exterior aspect. (×3)

carapace and about three times as wide as long. In the female, however, the larger chela is not so large as in that of the male and is less elongate in shape than in that of the opposite sex. But in the female specimens, the larger one has a better developed chela than the smaller specimen has. The smaller chela of the first leg is similar in feature in both sexes, but it seems to be somewhat different from the figure given by DE HAAN in " Fauna Japonica ".

Distribution: Japan: Tokyo Bay and Kagosima. I have examined some specimens of this species obtained from other localities such as Niigata-ken, Seto Inland Sea and the southern and north-western coasts of Tyôsen (Corea).

Hippolytidae ORTMANN

Genus SPIRONTOCARIS BATE

Spirontocaris ochotensis (BRANDT)

Japanese name: Hokkaimo-ebi

Hippolyte ochotensis BRANDT, 1851, p. 120, pl. 5, fig. 17; STIMPSON, 1860, p. 34.
Spirontocaris ochotensis, RATHBUN, 1904, p. 71, fig. 26 in text; BRASHNIKOW, 1907, p. 124.

Loc. Iigohama, 8,4 m. deep. July 18, 1935. 1 male.

The specimen contained in the collection is referable to the present species, but it differs from the type in some points.

The rostrum much exceeds the end of the peduncle of the first antenna, and is a little shorter than the antennal scale. On its upper margin there
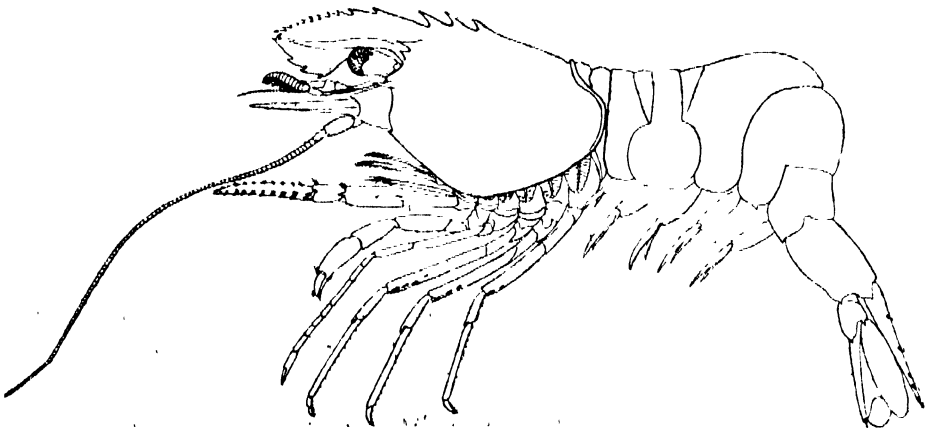
Fig. 4. *Spirontocaris ochotensis* (BRANDT) (x 5)

are ten minute teeth arranged in front of the three large teeth on the
carapace. Of the two flagella of the first antenna, the outer one is stout
and short, extending a little beyond the end of the rostrum, while the
inner slender one exceeds the end of the antennal scale.

Distribution: Sitka; Bering Island; Petropavlovsk, Kamchatka;
Okhotsk Sea; Japan: Hakodate Bay. It has hitherto not been known
from the coasts of Honsyû.

Spirontocaris onagawaensis n. sp.

Japanese name: Onagawamo-ebi

Loc. Takasiro, 7,5 m. deep. July 18, 1935. 1 probably male.
Nonohama, 4,6 m. deep. July 18, 1935. 1 probably male, infected
by a parasitic Isopoda.

The two specimens are probably of the same species, though some
different features are recognizable. The following description is based
chiefly on the specimen taken from Takasiro. The median carina of the
carapace is provided with five teeth, of which the posterior four are on
the carapace and the most posterior one lies near the middle of the
carapace excluding the rostrum, while in the specimen from Nonohama
six teeth are found on the median carina, the posterior five of which
are situated on the carapace and the most posterior one lies a little be-
hind the middle of the carapace excluding the rostrum. The terminal
half of the rostrum is provided with minute teeth placed on both the
upper and lower margins; the teeth being located 9 above and 3 below
in the specimen from Takasiro while in the other specimen 11 or 12 of
the teeth are above, and 4 are below. Of the two supraorbital teeth,
the upper anterior one is much stronger than the other. An antennal
tooth and a pterygostomian tooth are well developed. The abdomen is
moderately laterally compressed, being geniculated at the third somite.
The pleura of the anterior three abdominal somites are laterally rounded,
while those of the fourth and the fifth somites are pointed. The sixth
somite is a little longer than one half of the rostrum and is two-thirds
as wide as long. The telson is one and two-thirds times as long as the
sixth somite and is provided with four pairs of movable spinules on the
dorsal side.

The eye-stalk is moderately stout, with an ocellus on the upper surface,
just behind the margin of the cornea. The peduncle of the first antenna
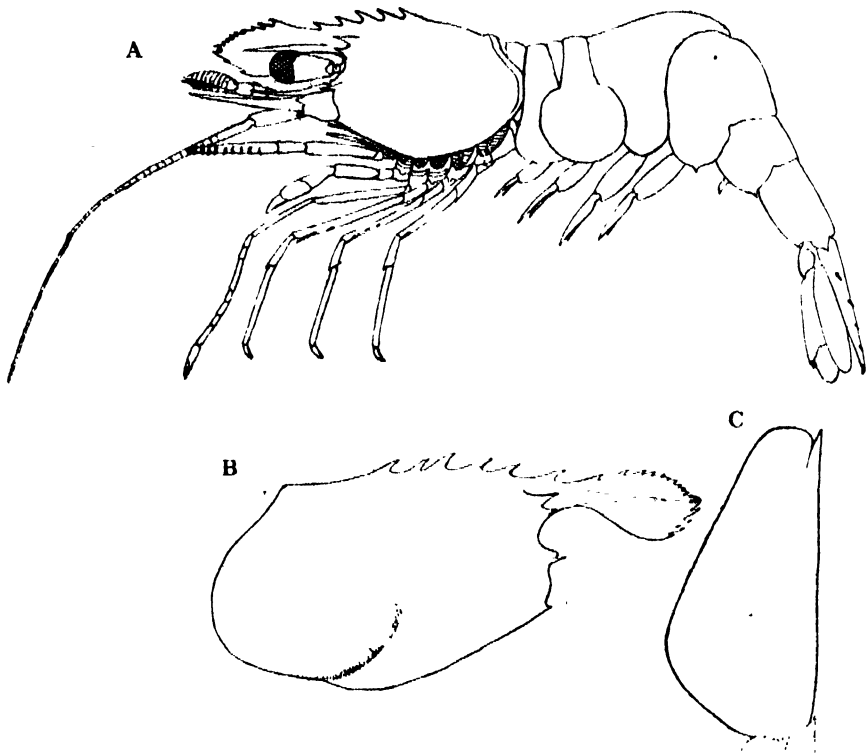
Fig. 5. *Spirontocaris onagawaensis* n. sp.

A. The specimen from Takasiro. (×6)

B. Carapace of the specimen from Nonohama. (×6).

C. Antennal scale of the same specimen. (×12)

reaches distally four-fifths of the rostrum, while in the specimen from Nonohama it reaches almost to the end of the rostrum. The stylocerite exceeds the end of the second peduncular joint. The antennal scale of the second antenna which reaches almost to the end of the outer stout flagellum of the first antenna, is about one half as wide as long. The third maxilliped and the anterior three legs are provided with epipodites. The third maxilliped bears an exognath, which attains to a proximal two-thirds of the antepenultimate joint of the endognath. The first leg is stouter than any of the other legs, exceeding the end of the penultimate joint of the third maxilliped by the length of the movable finger of the chela. The second leg is long and slender, exceeding the end of the antennal scale; of the seven carpal articles, the third is the longest of

all, and the terminal comes next, while the remaining five articles are
subequal in length, and the penultimate one seems to be somewhat shorter
than the others. The posterior three legs are subequal in feature, the
dactyli being short; the meri of the third and the fourth legs bear three
spinules on their terminal halves, while that of the last leg is provided
with a spinule near its distal end.

Siprontocaris geniculata (Stimpson)

Japanese name: Kosimagarimo-ebi

Hippolyte geniculata Stimpson, 1860, p. 34; Ortmann, 1891, p. 503, pl. 37, fig. 3.
Spirontocaris geniculata, Rathbun, 1902, p. 45; Yokoya, 1930, p. 530; 1933, p. 26.
Spirontocaris alcimede de Man, 1907, p. 416, pl. 32, figs. 42–46.

Loc. Iigohama, 8,4 m. deep. July 18, 1935. 3 males and 10 females.
   Takasiro, 7,5 m. deep. July 18, 1935. 1 male and 1 female.
   Onmae Bay, 10 m. deep. July 24, 1935. 1 male and 1 female.
   Onagawa Harbour, 8 m. deep. August 2, 1935. 1 female infected
   by a parasitic Isopoda.
Rostral teeth 5 or 6 above, from 7 to 9 below.
Distribution: Japan: Hakodate, Muroran, Tanagawa, Tokyo Bay,
Inland Sea, north of Oga, Mutu Bay and localities above mentioned.

Spirontocaris rectirostris (Stimpson)

Japanese name: Asinagamo-ebi

Hippolyte rectirostris Stimpson, 1860, p. 33; Doflein, 1902, p. 637, pl. 3, fig. 7.
Spirontocaris rectirostris, de Man, 1907, p. 411, pl. 32, figs. 31–34; Balss, 1914, p. 43.

Loc. Konorihama, 12 m. deep. June 15, 1935. 1 male and 1 young.
   Isihama, 10 m. deep. June 16, 1936. 3 females.
   Onagawa Harbour, 8 m. deep. August 2, 1935. 1 female.
Distribution: Japan: Hakodate, Aomori, Nagasaki, Inland Sea, Sagami
Bay and the above mentioned localities.

Spirontocaris pandaloides (Stimpson)

Japanese name: Tunonagamo-ebi

Hippolyte pandaloides Stimpson, 1860, p. 34; Doflein, 1902, p. 637, pl. 5, fig. 3.
Spirontocaris pandaloides de Man, 1907, p. 418, pl. 32, figs. 47, 48; Yokoya, 1930, p.
   530.

Loc. Onmae Bay, 18 m. deep. July 15, 1935. 1 female.
　　　　　„　　10 m. deep. July 24, 1935. 1 male.
Iigohama, 8,4 m. deep. July 18, 1935. 3 males.
Onagawa Harbour, 8 m. deep. August 2, 1935. 2 females.
Takasiro, 7,8 m. deep. July 18, 1935. 2 youngs.
Distribution: Hakodate to Inland Sea of Japan ; Corean Strait.

Spirontocaris minuta YOKOYA

Japanese name : Himemo-ebi

YOKOYA, 1930, p. 531, textfig. 2; 1933, p. 28, textfig. 11.

Loc. Yokoura, 21 m. deep. July 18, 1935. 2 females.

In both of these specimens, the rostral teeth are 6 both above and below.

Distribution: Japan : Mutu Bay ; Sado Isl. and Oga ; above mentioned locality.

Spirontocaris japonica YOKOYA

Japanese name : Yamatomo-ebi

YOKOYA, 1930, p. 533, textfig. 3.

Loc. Iigohama, 8,4 m. deep. July 18, 1935. 1 egg-bearing female.
　　Nonohama, 4,6 m. deep. July 18, 1935. 2 females, 1 of which bears eggs.
　　Yokoura, 21 m. deep. July 18, 1935. 1 egg-bearing female.
　　Onmae Bay, 10 m. deep. July 24, 1935. 4 males.
　　Koyatori, at the beach. July 30, 1935. 3 males.
　　Onagawa Harbour, 8 m. deep. August 2, 1935. 5 females.

The original description of the species given by me was based upon four young or immature specimens. Now examining many maturated specimens, I should like to describe it here once more.

The rostrum is about one and one-third times as long as the rest of the carapace, and is provided with four or five or rarely six teeth above, and with three or four or rarely two teeth below. Of the teeth found on the upper margin one is behind the eye and the next one stands just above the orbital crescent. The eye-stalk is rather long, nearly cylindrical, distally gradually inflated. The cornea is a little inflated, in the alcoholic specimen a small round black spot is noticeable near the margin of the pale black cornea. In the first antenna, the stylocerite reaches to the

end of the proximal peduncular joint, which is twice as long as the succeeding two peduncular joints combined. The proximal and the next peduncular joints are pointed distally at the outer margin. The scapho-cerite of the second antenna is nearly as long as the rostrum. The third maxilliped somewhat exceeds the proximal two-thirds of the antennal scale, the exognath is a little longer than two-thirds of the antepenultimate
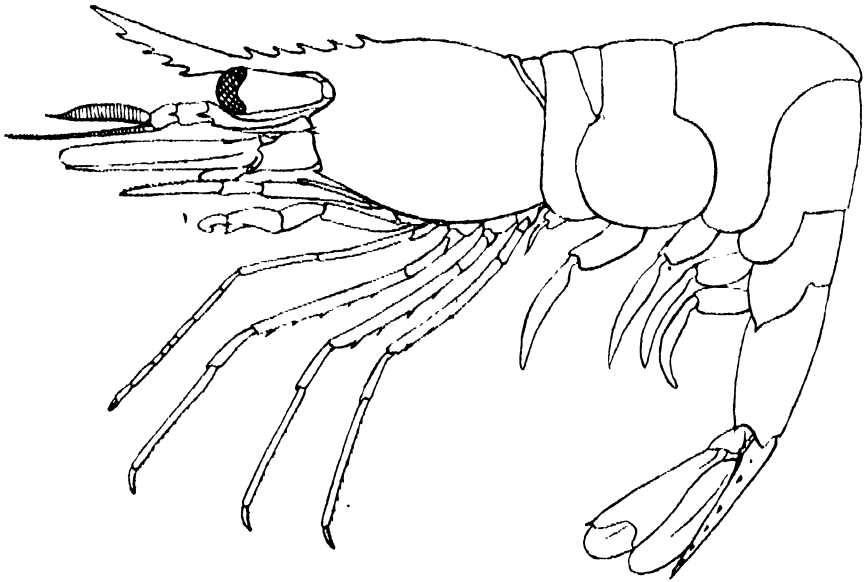
Fig. 6. *Spirontocaris japonica* YOKOYA. (×7)

segment of the endognath. The first leg is robust; the second is slender; of the carpal articles the second is the longest of all and the terminal is a little longer than either the first or the third, the latter two are subequal in length; the remaining three articles are very short and those combined are still shorter than the second.

The posterior three legs are similar in feature, meri are provided with five, four and three spinules placed on the posterior margins of the third, fourth and fifth legs respectively.

The abdomen was shown in the previous description, but the telson is provided with five pairs of spinules which are seen in the dorsal aspect.

Distribution: Japan: Mutu Bay and Onagawa.

Genus LATREUTES STIMPSON

Latreutes planirostris (DE HAAN)

Japanese name: Hiratunomo-ebi

Cyclorhynchus planirostris DE HAAN, 1849, p. 175, pl. 45, fig. 7.
Rhynchocyclus planirostris, STIMPSON, 1860, p. 27.
Latreutes planirostris, ORTMANN, 1891, p. 505, pl. 37, figs. 4 d-l, 4 n; DE MAN, 1907, p.
     421.
Platybema planirostre, RATHBUN, 1902, p. 46.

Loc. Koyatori, sandybeach. July 30, 1935. 1 male.
     Onagawa Harbour, 8 m. deep. August 2, 1935. 1 egg-bearing
female.

Distribution: Japan: Hakodate, Inland Sea, Ariake Bay, Kagosima,
Tokyo Bay and the above mentioned localities.

Latreutes dorsalis STIMPSON

Japanese name: Ôtunomo-ebi

STIMPSON, 1860, p. 27.

Loc. Onagawa Harbour, 8 m. deep. August 2, 1935. 1 male.

This species has not been reported since STIMPSON first described it
from Hakodate, Hokkaidô. I should like here to describe it once more.

The medial obtuse carina of the carapace is armed with a pointed
tooth and a tubercle, and is continuous with the rostrum which is a little
longer than the carapace. The rostrum is knife shaped and is about
one-third as wide as long; the upper margin is concave and is armed
with eight minute teeth distributed on the distal half, while on the lower
margin there are six of these. The antennal spine is distinct, and seems
to be jointed; at the antero-lateral corner of the carapace there are eight
or nine minute but sharply pointed teeth. The eye-stalk is rather short.
Two flagella of the first antenna are subequal in length, reaching to the
end of the rostrum, and are a little longer than twice the length of the
peduncle; the outer flagellum is proximally stout and very thickly fringed
with downy hairs. The stylocerite is rather short, the proximal peduncular
joint is furnished with a short pointed tooth on the outer distal end, the
succeeding two joints are obliquely articulated with each other. In the
second antenna the flagella are missing on both sides; the scaphocerite is
almost as long as the carapace, and is pointed distally forming an elongated
triangle. The third maxilliped is short and robust, attaining the level of
the peduncular end of the first antenna. The first leg also is robust and

reaches to the end of the penultimate joint of the third maxilliped. The succeeding four pairs of legs are slender. The second leg exceeds the end of the third maxilliped; of the carpal articles, the proximal and the distal ones are subequal in length and the intermediate one is the longest.
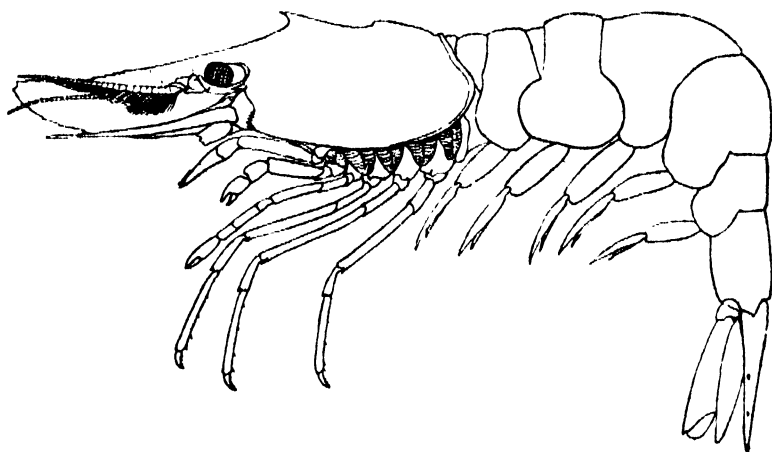
Fig. 7. *Latreutes dorsalis* STIMPSON. (×6)

The posterior three pairs of legs are subequal in length as well as in feature and are longer than any of the preceding pairs of legs. The merus is provided with a pointed tooth near the distal end and on the inferior margin; the dactylus is rather short with five or six spines on the posterior magin. There is no epipodite on the base of any of the walking legs.

The second to fourth abdominal somites are dorsally obtusely carinate on the middle line, and the others are rounded. The sixth somite is nearly one and one-half times as long as the fifth, and is three-fifths as long as the telson. The telson is armed with two pairs of marginal spinules and the posterior end is sharply pointed; on each side of this point there is a spinule. The sixth abdominal appendage does not exceed the end of the telson, and the "diaresys" of the outer plate is placed very obliquely.

Crangonidae BATE

Genus CRANGON FABRICIUS

Crangon affinis DE HANN

Japanese name: Zako-ebi

DE HAAN, 1849, p. 183; YOKOYA, 1930, p. 541; 1933, p. 32.

Loc. Iigohama, 8,4 m. deep. July 18, 1935. 2 males and 3 egg-bearing
females.

Yokoura, 28 m. deep. July 18, 1935. 1 egg-bearing female.

Kosikine, 19 m. deep. July 18, 1935. 1 infected male and 1 female.

Koyatori Inlet, 14 m. deep. July 19, 1935. 1 male.

     ,,   18 m. deep. ,,   ,,   ,,   1 male and 2 females.

Siranezaki, 34 m. deep. July 20, 1935. 4 females, of which 1
bears eggs.

Takozima, 26 m. deep. July 20, 1935. 1 male and 1 egg-bearing
female.

Ôura Bay, 8 m. deep. July 24, 1935. 1 infected male and 3 fe-
males, 1 of the females bears eggs.

Takenoura, 15 m. deep. October 14, 1935. 1 egg-bearing female.

Isihama, 10 m. deep. June 16, 1936. 5 males and 12 females, 10
of the females bear eggs.

Most of the male specimens are infected by parasitic Isopoda, *Bopyrus.*
In male specimens the thoracic sternum is different in structure from that
of the female. The thoracic sternum of the male is provided with four

A   B
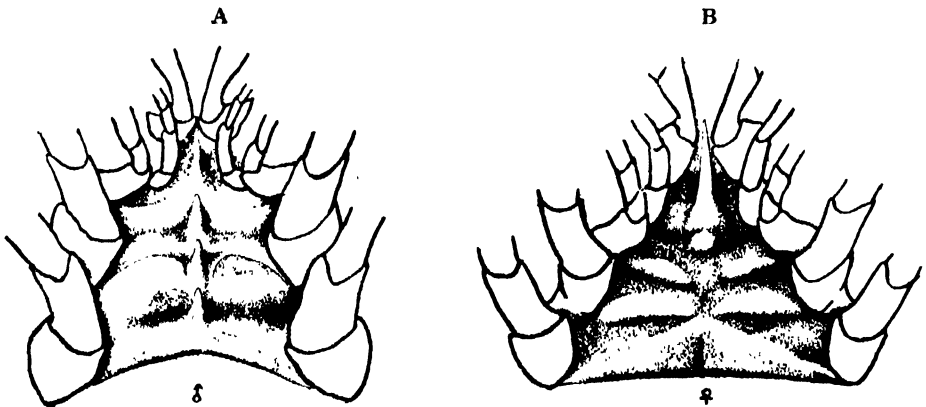
Fig. 8. Thoracic sternum of *Crangon affinis* DE HAAN.
A. of a male.   B. of a female.

sharply pointed teeth on the medial line, each one being placed in the
middle between the legs of each pair of posterior four legs; and there
are two pairs of transverse ridges, situated on each side of the second
and the third medial teeth. In the female, however, the thoracic sternum
has a strong tooth between the bases of the second pair of legs, and an
obtuse tubercle is found just behind this tooth. The transverse ridges of

the female are more obtuse than those of the male.

Distribution: Japan and Tyôsen (Corea).

Crangon dalli RATHBUN

Japanese name : Daruzako-ebi

RATHBUN, 1902, p. 889; 1904, p. 119, textfig. 60; YOKOYA, 1933, p. 33.

Loc. Off Ozaki, about 130 fathoms deep. December 23, 1935. 1 female.

Distribution: Washington ; Alaska ; Kurile Islands. Japan : East of northern Honsyû.

Crangon communis RATHBUN

Japanese name : Tyairozako-ebi

RATHBUN, 1899, p. 556; 1904, p. 123, textfig. 64; YOKOYA, 1933, p. 34.
Crago communis, SCHMITT, 1921, p. 95, fig. 63.

Loc. Off Ozaki, about 130 fathoms deep. December 23, 1935. 3 females.

Distribution: From Bering Sea to San Diego, California ; Kamtchatka. Japan : northern Honsyû.

Genus NECTOCRANGON BRANDT

Nectocrangon hozawai n. sp.*

Japanese name : Hozawawatari-ebi

Loc. About 5 miles off Ozaki, 130 fathoms deep. December 23, 1935. 1 female.

Near *Nectocrangon lar* (OWEN), but differing in the following points :

On the median carina of the carapace, there is a distinct tubercle besides two pointed teeth, and it is laterally compressed and is situated in front of the anterior median tooth. Of these two medial teeth, the anterior one is at the anterior third of the carapace, and at a point a little behind the half way mark from this tooth of the posterior carapace margin there is the other tooth. The median carinae of the abdominal somites are high and are more strongly laterally compressed and are more acute than those of *N. lar;* paired carinae of the sixth abdominal somite are distinctly extended to the posterior margin of the somite.

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* The species is named in honour of Prof. S. HÔZAWA.

On this margin there are two obtuse lobes which are continuous to the carinae. The chela of the first leg is three and two-thirds times as wide as long.
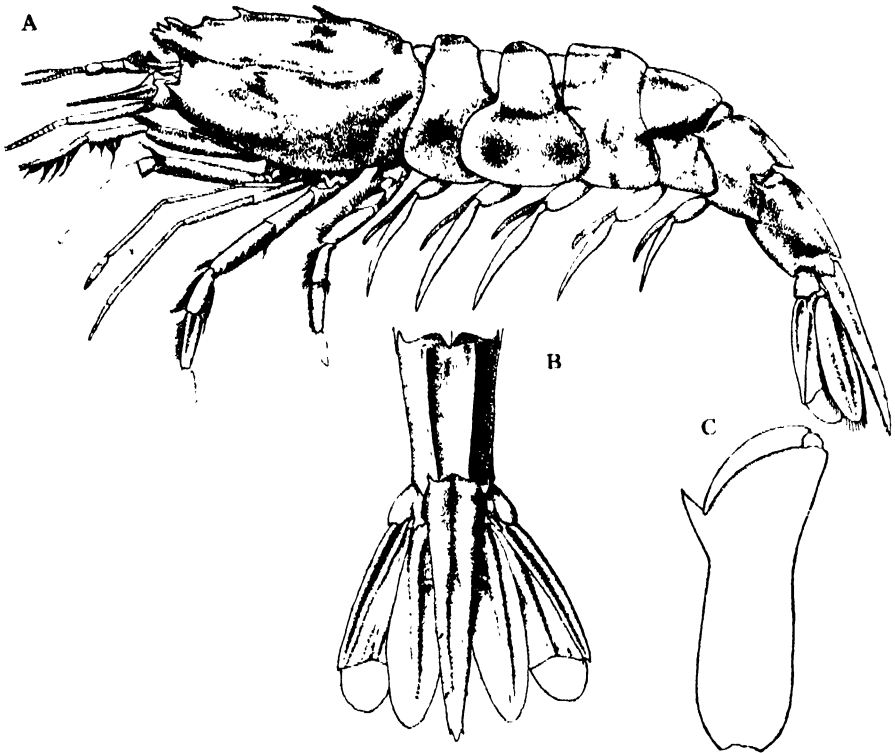
Fig. 9. *Nectocrangon hozawai* n. sp.
A. Entire animal, left aspect. (×1½)
B. Posterior two abdominal somites, dorsal aspect. (×2)
C. Chela. (×8)

The colour of the alcoholic specimen is pale ochre yellow and brownish bands found on the carapace are almost transverse, while those of the abdomen are oblique.

Callianassidae BATE

Genus CALLIANASSA LEACH

Callianassa petalura STIMPSON

Japanese name: Sunamoguri

STIMPSON, 1860, p. 23.
Callianassa subterranea japonica ORTMANN, 1892, p. 56, pl. 1, fig. 10 a; DOFLEIN, 1902, p. 644; BAISS, 1914, p. 91; YOKOYA, 1930, p. 543; 1933, p. 52.

Loc. Kirigasaki, sandy beach, August 14, 1935. 2 males and 1 egg-bearing female.

Onmae, sandy beach. August 26, 1935. 1 young specimen.

Konorihama, sandy beach. May 15, 1934. 1 male.

Distribution: Japan: Around Honsyû, Sikoku and Kyûsyû.

Genus UPOGEBIA LEACH
Upogebia issaeffi BALSS
Japanese name: Kita-anazyako

BALSS, 1913 a, p. 239; 1914, p. 89, figs. 48, 49.

Loc. Konorihama, sandy beach. May 15, 1934. 2 females.

Distribution: Vladivostock; it has never hitherto been reported from Japanese waters.

ANOMURA
Porcellanidae HENDERSON
Genus PACHYCHELES STIMPSON
Pachycheles stevensii STIMPSON
Japanese name: Kanimodoki

STIMPSON, 1858, p. 242; 1907, p. 187, pl. 23, fig. 6; MIERS, 1879, p. 47; ORTMANN, 1892, p. 267; 1897, p. 294; BALSS, 1913 b, p. 32.

Loc. Isihama beach. July 14, 1935. 1 male and 1 egg-bearing female.

Yatarôzima, 34 m. deep. July 23, 1935. 1 male.

Sannôzima beach. July 30, 1935. 1 male.

Distribution: Vladivostock; Hokkaidô; Japan: Tokyo Bay, Nagasaki and the localities above mentioned.

Paguridae DANA
Subfamily Pagurinae ORTMANN
Genus PAGURISTES DANA
Paguristes barbatus ORTMANN
Japanese name: Hukage-yadokari

Paguristes barbatus (HELLER) ORTMANN, 1892, p. 279, pl. 12, fig. 7; ALCOCK, 1905, p. 155; DOFLEIN, 1902, p. 645; BALSS, 1913 b, p. 39; YOKOYA, 1933, p. 74.

Loc. Izusima Harbour, 28 m. deep. July 17, 1935. 1 male.

Takenoura, 23 m. deep. July 18, 1935. 4 males.

Kosikine, 19 m. deep. July 18, 1935. 6 males and 11 females, 9 of which bear eggs.

Siranezaki, 34 m. deep. July 20, 1935. 2 males.

Ôisozaki, 36 m. deep. July 20, 1935. 4 males and 7 females, 6 of which bear eggs.

Near Izusima, 31 m. deep. July 22, 1935. 1 female.

Onagawa Bay, 39 m. deep. July 22, 1935. 2 males and 4 females, 3 of which bear eggs.

Onagawa Harbour, August 3, 1935. 6 males and 1 female.

The specimens coincide with the description given by ORTMANN, but the branchiae are 11 in number, as a podobranchia is found on the third maxilliped in addition to the branchial formula given by him. Two pairs of abdominal appendages are developed in the male and are similar in feature to those of *Paguristes digitalis* STIMPSON. The figures of paired

A   B
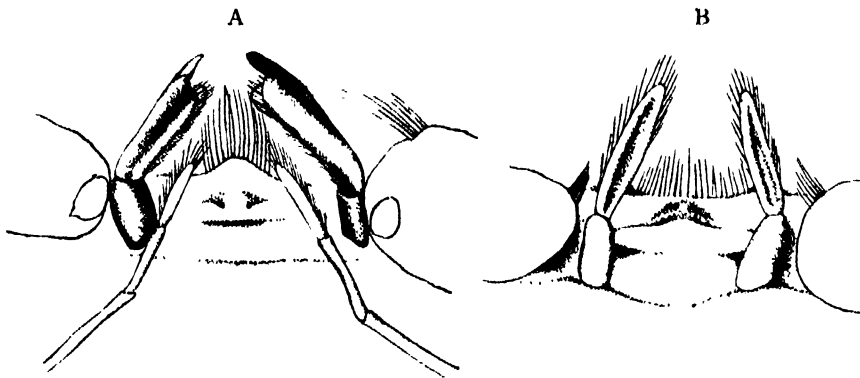
Fig. 10. *Paguristes barbatus* ORTMANN.
A. Posterior part of thoracic sternum, showing two pairs of abdominal appendages of a male.
B. Posterior part of thoracic sternum, showing a pair of abdominal appendage of a female.

abdominal appendages of the latter species were shown by BALSS in 1913. The anterior pair is stout and two-jointed, while the posterior is slender and three-jointed in both of the species. Of the anterior pair, the basal joint is short and stout, but the terminal joint is flattened and is some-what longer than three times the length of the basal. It consists of three portions: a dorsal lobe, a ventral lobe and a terminal projection. The dorsal and the ventral lobes are folded into each other along the outer

margin, and near the distal end of this margin the terminal projection arises. The dorsal lobe is shorter than that of *Paguristes digitalis* and the ventral lobe is provided with minute tubercles on the margins and on its ventral surface. In the female, the posterior pair is degenerated and the terminal joint of the anterior pair is simple in structure.

Distribution: Japan: On the Pacific side, being found in the localities along the line extending southwards of Onagawa to Sikoku. In the Japan Sea it is reported from Nagato and Noto.

Paguristes digitalis STIMPSON

Japanese name: Menaga-yadokari

STIMPSON, 1858, p. 247; 1907, p. 212, pl. 25, fig. 1; BALSS, 1913 b, p. 37, figs. 26, 27; YOKOYA, 1933, p. 73.

Loc. Kosikine, 19 m. deep. July 18, 1935. 2 males and 3 egg-bearing females.

Distribution: Japan: Hakodate, Tugaru Strait, Sagami Bay, Tusima Strait and above mentioned locality.

Genus DIOGENES DANA

Diogenes edwardsii (DE HAAN)

Japanese name: Edwaruzi-yadokari

Pagurus edwardsii DE HAAN, 1849, p. 211, pl. 50, fig. 1.
Diogenes edwardsii, STIMPSON, 1858, p. 246; 1907, p. 202, pl. 24, fig. 1; ORTMANN, 1892, p. 295; RATHBUN, 1902, p. 37; BALSS, 1913 b, p. 44; TERAO, 1913, p. 362; YOKOYA, 1933, p. 77.

Loc. Samenoura Bay, 21 m. deep. July 23, 1935. 4 males and 1 egg-bearing female.

Onagawa Harbour, 10 m. deep. August 3, 1935. 1 male.

Distribution: China Sea; Hongkong; Japan: Tokyo Bay, Bôsyû, Sagami Bay, Inland Sea, Nagasaki and near Lake Hamana-ko. North of Kinkazan it has hitherto not been known.

Subfamily Eupagurinae ORTMANN

Genus EUPAGURUS BRANDT

Eupagurus pectinatus STIMPSON

Japanes name: Kusi-yadokari

STIMPSON, 1858, p. 249; 1907, p. 220; BALSS, 1913 b, p. 60, fig. 35, pl. 1, fig. 8; YOKOYA, 1933, p. 83.

Loc. Onmae Bay, 18 m. deep. July 16, 1935. 1 female in a sponge.

       „   12 m. deep. July 17, 1935. 1 female.

    Kosikine, 25 m. deep. June 2, 1935. 1 female.

Distribution: Castri Bay; Japan: Tugaru Strait, Hakodate, off the mouth of the River Mogami, Sado Isl., Toyama Bay and Corea Strait. From the Pacific side of Honsyû, it has not hitherto been reported.

Eupagurus gracilipes STIMPSON
Japanese name: Hosoasi-yadokari

STIMPSON, 1858, p. 248; 1907, p. 217; DOFLEIN, 1902, p. 647, pl. 6, figs. 6-8; ALCOCK, 1905, p. 177; BALSS, 1913 b, p. 56.

Eupagurus nipponensis YOKOYA, 1933, p. 87, textfig. 32. (not *E. gracilipes* YOKOYA, l.c. p. 89, textfig. 33).

Loc. Okati Bay, 35 m. deep. July 17, 1935. 1 female.

    Siranezaki, 34 m. deep. July 20, 1935. 1 male.

    Ôisozaki, 36 m. deep. July 20, 1935. 1 male.

    Samenoura Bay, 21 m. deep. July 23, 1935. 1 male and 1 female.

    Onagawa Harbour, 10 m. deep. August 3, 1935. 1 male.

Distribution: Japan: Tugaru Strait, Sagami Bay, Tokyo Bay, Suruga Bay, Kosiki Isls., Gotô Isls. and above mentioned localities.

Eupagurus middendorffii BRANDT
Japanese name: Ibo-yadokari

Pagurus (Eupagurus) middendorffii BRANDT, 1851, p. 108, pl. 5, figs. 1 16.

Pagurus middendorffii, RATHBUN, 1902, p. 646; 1904, p. 160.

Eupagurus middendorffii, DOFLEIN, 1902, p. 646; ALCOCK, 1905, p. 178; STIMPSON, 1907, p. 226; BALSS, 1913 b, p. 58.

Loc. Tukahama, 9 m. deep. July 18, 1935. 1 male and 1 egg-bearing female.

    Nonohama, 4,6 m. deep. July 18, 1935. 1 male.

The fingers of the chelae, especially the left one, open and close obliquely downwards. Hands and wrists are granular on both sides, and these excepting the left wrist are devoid of hairs. Granules of the chelipeds seem to the naked eye to be flattened, but under magnifying lens they are nearly conical, though the tips are rounded. The colour of the alcoholic specimen is pale orange and a number of brownish bands are seen on the chelipeds as well as on the succeeding two pairs of legs. The specimens which I have dealt with are referable to the present species, though the carpus of the cheliped is comparatively shorter.

Distribution : Northern California ; Bering Sea ; Castri Bay ; Okhotsk Sea ; Northern Japan.
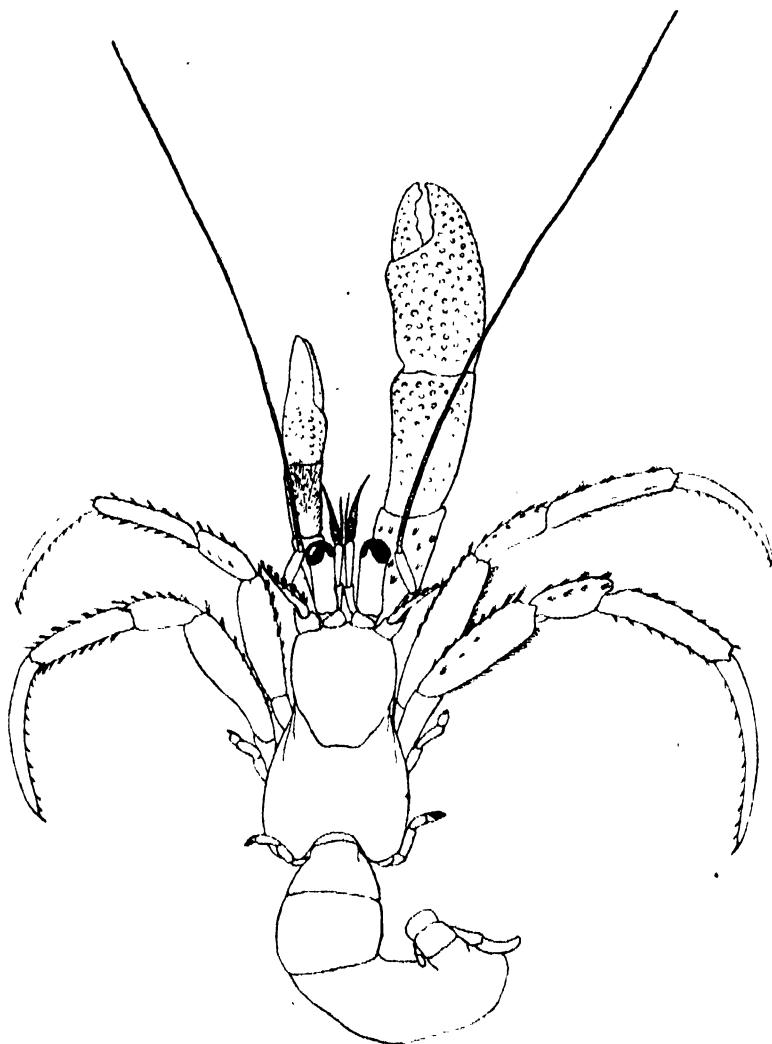
Fig. 11. *Eupagurus middendorffii* BRANDT. (×6)

Eupagurus brachiomastus THALLWITZ
Japanese name : Ikubi-yadokari

THALLWITZ, 1891, p. 35; ORTMANN, 1892, p. 312.

Loc. Kosikine, 19 m. deep. July 18, 1935. 2 males and 3 egg-bearing

females.

Siranezaki, 34 m. deep. July 20, 1935. 2 females, 1 of which bears eggs.

Onagawa Harbour, 10 m. deep. August 3, 1935. 2 females.

The specimens referable to the present species seem to be rather rare in Japan, as this species has not been reported, as far as I know, since THALLWITZ first described it from Japan or China.

The anterior half of the carapace is smooth and polished in the middle
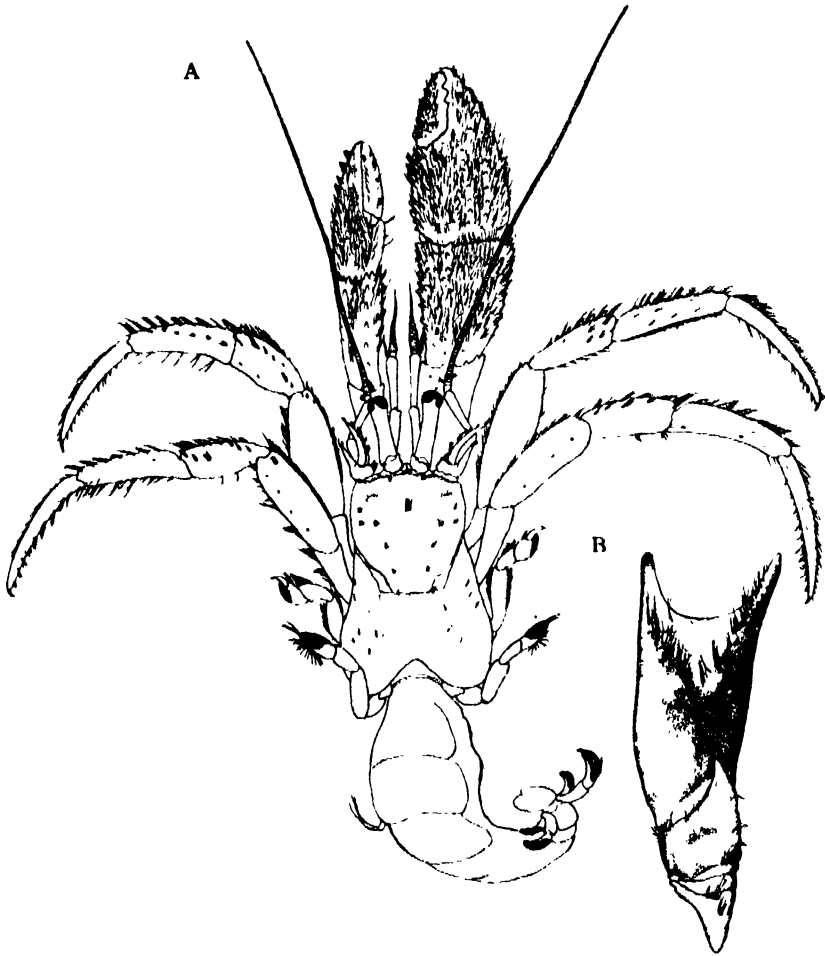
Fig. 12. *Eupagurus brachiomastus* THALLWITZ.
A. Entire animal, dorsal aspect. (×3)
B. Basi-ischium and merus of the larger cheliped, ventral aspect. (×6)

except the part a little back of the frontal margin. The rostral tooth
projects forwards, the lateral tooth is obsolete. The eye-stalk is a little
longer on the right side. The penultimate peduncular joint of the first
antenna reaches almost to the end of the eye-stalk. The peduncle of the
second antenna exceeds the end of the eye, while its styliform scale scarcely
reaches the end of the eye-stalk. The chelipeds are hairy, the hairs on the
dorsal surfaces of the chelae and of the carpi are especially dense and long,
covering the spinulous tubercles found on them. The carpus of the right
larger cheliped is a little longer than two-thirds the length of the chela,
of which the finger is a little shorter than the palm. The merus is
provided with a number of tubercles on the anterior half of the inferior
margin ; and among these tubercles two situated near the middle of the
the margin are the most prominent. In the left cheliped, the carpus is
about four-fifths as long as the chela, of which the finger is one and a half
times as long as the palm ; and no prominent tubercle is noticeable on
the inferior margin of the merus. Of the succeeding two pairs of walking
legs, the right ones are a little longer than the corresponding legs on
the left side ; and in the anterior pair the carpi and propodi are provided
with a series of spinulous tubercles arranged on their superior margin.
   Distribution : Japan or China ; Castri Bay and the above mentioned
localities.

Eupagurus dubius ORTMANN
Japanese name : Gihokkai-yadokari

ORTMANN, 1892, p. 307, pl. 12, fig. 14; DOFLEIN, 1902, p. 646; BALSS, 1913 b, p. 55;
      YOKOYA, 1933, p. 81.

Loc. Ôisozaki, 36 m. deep. July 20, 1935. 1 male.
Distribution : Japan : Tokyo Bay, Sagami Bay, Mie-ken, Tusima Isl.
and the above mentioned locality.

Eupagurus ochotensis BRANDT
Japanese name : Hokkai-yadokari

Pagurus (Eupagurus) bernhardus var. C, *spinimana ;* or sp. *ochotensis* BRANDT, 1851, p.
      108.
Pagurus ochotensis, BENEDICT, 1901, p. 463; RATHBUN, 1904, p. 157; SCHMITT, 1921, p.
      130.
Eupagurus ochotensis, STIMPSON, 1907, p. 218; BALSS, 1913 b, p. 60; YOKOYA, 1933, p.
      82.
Bernhardus armatus DANA, 1852, p. 442, pl. 27, fig. 2.
Eupagurus ortmanni BALSS, 1911, p. 7.

Loc. Samenoura Bay, 21 m. deep. July 23, 1936. 1 female.

Distribution: From Vancouver Isl. to San Diego, California ; Okhotsk Sea ; Aniwa Bay ; Vladivostock ; Japan : From Tugaru Strait to Inuboezaki on the Pacific side and from the same strait to Sado Isl. on the side of the Japan Sea.

Eupagurus constans STIMPSON

Japanese name : Igaguri-yadokari

STIMPSON, 1858, p. 248; 1907, p. 218, pl. 24, fig. 3; HENDERSON, 1888, p. 67, pl. 6, fig. 8; ORTMANN, 1892, p. 320; DOFLEIN, 1902, p. 647; ALCOCK, 1905, p. 177; BALSS, 1913 b, p. 55; TERAO, 1913, p. 366; YOKOYA, 1933, p. 81.

Loc. Takenoura Bay, 12 m. deep. August 14, 1935. 1 female.

Onagawa Harbour, 10 m. deep. August 2, 1935. 2 males and 1 female.

Distribution: Japan : From Tugaru Strait to Lake Hamana on the Pacific side, while on the opposite side it has been known from Oga and from Nagasaki.

Eupagurus obtusifrons ORTMANN

Japanese name : Tankaku-yadokari

ORTMANN, 1892, p. 313, pl. 12, fig, 18; YOKOYA, 1933, p. 85.

Loc. Konorihama, 15 m. deep. November 15, 1935. 2 males.

Distribution: Japan : Siwoyazaki to Bungo Strait and Tugaru Strait. Onagawa seem to be the connection between Tugaru Strait and Siwoyazaki.

Eupagurus imaii n. sp*.

Japanese name : Imai-yadokari

Loc. Siranezaki, 34 m. deep. July 20, 1935. 1 male.

The rostrum strong, sharply pointed and almost attaining the middle of the ophthalmic scale. The lateral teeth are distinct but are much shorter than the rostral horn. The anterior half of the carapace is almost smooth surfaced, and a little longer than one and a half times the length of the posterior half when measured on the medial line. The posterior half of the carapace is soft, but a longitudinal calcified area is found on each side of the cardiac region.

The eye-stalk is moderately stout, a little longer than the antennal acicule, but distinctly shorter than the peduncle of the second antenna.

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* In honour of Dr. TAKEO IMAI.

The peduncle of the first antenna is much longer than the peduncle of the second antenna, when it extends forwards. The chelipeds are hairy, the right one being much larger than the left, the merus is furnished with granular teeth on the inferior margins, while the superior surface
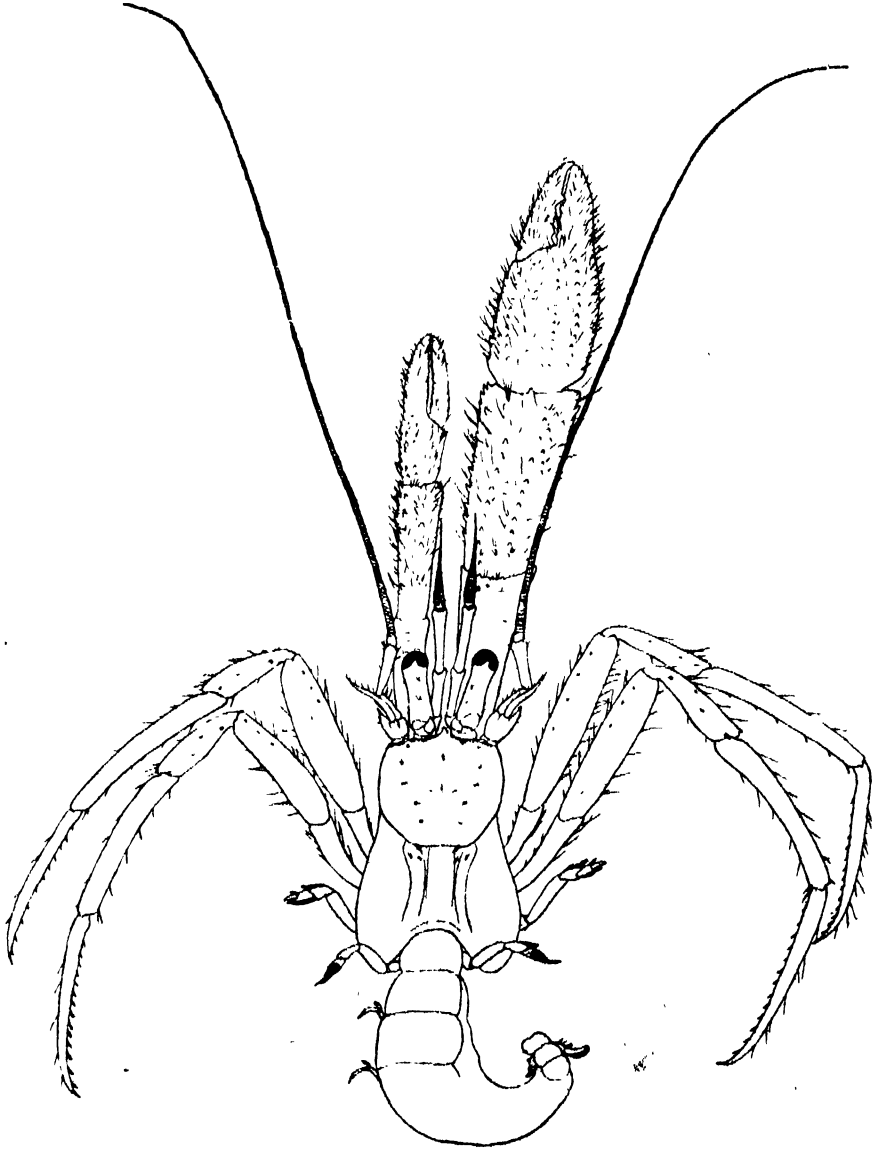
Fig. 13. *Eupagurus imaii* n. sp. (×6)

is somewhat tubercular and almost naked. The carpus is four-fifths as long as the chela in the right hand, while it is nearly seven-eighths as long in the left. The finger is a little longer than four-fifths of the palm in the right hand, while in the left it is almost twice as long as the palm ; and the inner margin of the finger is provided with one or two stronger teeth besides a number of small ones in the right hand, while in the smaller left hand, in place of the teeth, there is a series of tubercular small lobes of almost equal size. The walking legs are slender, and are hairy on the superior and the inferior margins, and the right leg is somewhat longer than the left leg. In the anterior pair of the walking legs, the propodus is nearly as long as the dactylus, while in the posterior pair the former is somewhat but distinctly shorter than the latter.

This species is closely allied to *Eupagurus anomalus* BALSS. However, the rostral horn in the present species is not only weaker, but the surface of the carapace and the walking legs also are not so strongly sculptured as are those of *Eupagurus anomalus*.

Lithodidae BOUVIER

Genus HAPALOGASTER BRANDT

Hapalogaster dentatus (DE HAAN)

Japanese name : Ibotoge-gani

Lomis dentata DE HAAN, 1849, p. 219, pl. 48, fig. 2.
Hapalogaster dentatus, STIMPSON, 1858, pp. 232, 245; 1907, p. 198; ORTMANN, 1892, p. 323; MIERS, 1879, p. 47; BALSS, 1913, p. 71; YOKOYA, 1928, p. 758.

Loc. Iigohama, beach. July 31, 1935. 2 males and 1 female.

The male has no abdominal appendages, but in the female they are seen on the left side.

Distribution : Vladivostock ; Japan : from Nagasaki to Hokkaidô.

Genus OEDIGNATHUS BENEDICT

Oedignathus inermis (STIMPSON)

Japanese name : Ibo-gani

Hapalogaster inermis STIMPSON, 1860 a, p. 243.
Dermaturus inermis, BALSS, 1913 b, p. 71 (cited other previous literature and synonyms).
Oedignathus inermis, SCHMITT, 1921, p. 151, pl. 19, fig. 1; YOKOYA, 1925, p. 769.

Loc. Isihama beach, July 14, 1935. 2 young males and 2 young females.
Iigohama beach, July 31, 1935. 1 male and 1 female.

Distribution: From Unalaska, to Pacific Grove, California ; Hokkaidô ; Japan : Aomori, Tusima Isl. and above mentioned localities.

Genus CRYPTOLITHODES BRANDT

Cryptolithodes expansus MIERS

Japanese name : Menko-gani

MIERS, 1879, pp. 21, 49; RATHBUN, 1902, p. 32, textfig. 1; BALSS, 1913 b, p. 71, pl. 1, figs. 6, 7, textfig. 55.

Loc. Onmae Bay, 8 m. deep. July 17, 1935. 1 young female.

Yokoura, 28 m. deep. July 18, 1935. 1 female.

Even in the larger specimen from Yokoura, the carapace is 19,8 mm. long and 25,4 mm. wide.

Distribution: Japan : Rikuzen and Aomori.

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EMBRYOLOGICAL OBSERVATIONS ON *THUJOPSIS DOLABRATA* VAR. *HONDAI* MAKINO

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(With Plate XIII-XV and 6 text-figures)

(Received May 26, 1939)

INTRODUCTION

Thujopsis dolabrata is a plant endemic to Japan and one variety of it var. *Hondai* MAKINO is distributed in the northern part of Japan proper, and in South Hokkaidô. Regarding the embryological study of this genus, KAPFER ('35) states that the development of the proembryo and embryo agrees with that of *Thuja occidentalis,* but he has not carried out detailed description and illustration. During the last two years the present writer has made minute embryological observations on this plant.

This work has been carried out under the suggestions and criticisms of Professor Dr. M. TAHARA, to whom the writer wishes to express his hearty thanks.

MATERIAL AND METHOD

The material used in the present work, was collected from a cultivated tree in the grounds of the Sendai Forestry Office.

With regard to the technique of the examination, for the pollen mother-cell and the pollen grain the smear method, for the development of the female gametophyte the usual paraffin serial section, and for the embryogeny BUCHHOLZ's dissection method were used. The smear preparations were fixed by TAYLOR's solution and were stained by NEWTON's gentian violet iodine or HEIDENHAIN's haematoxylin. The material for the paraffin section was fixed by chrom-acetic strong solution after dipping the material into CARNOY's triple solution for several minutes. For staining in this case, HEIDENHAIN's haematoxylin or FEULGEN's nuclear staining was used. The dissected out embryo, after being fixed by chrom-acetic strong solution, was stained by ruthenium red and gentian violet and then mounted into Canada balsam, but sometimes the embryo, stained only by ruthenium red, was investigated in water.

MICROSPOROGENESIS AND MALE GAMETOPHYTE

The archesporial tissue is surrounded by a layer of tapetum in which binucleate cells are seen in a later stage. In the outside of the tapetum, two layers of the wall cells are found.

The meiosis of the pollen mother-cells takes place in the middle of February in Sendai. The pollen mother-cell is ellipsoid or ovoid in shape and contains many granular substances in the cytoplasm. Leptotene, zygotene, pachytene, diplotene stages and diakinesis are typically distinguished in prophase (Pl. XIII, figs. 1–8) but in zygotene stage, synizesis does not appear, that is, the spiremes in the stage do not contract in a part of the nucleus (Pl. XIII, fig. 3). In metaphase eleven bivalents are clearly counted in a polar view (Pl. XIII, fig. 9), but in the aceto-carmine smear preparation the counting of the chromosomes is very difficult, owing to the existence of numerous granular substances in the cytoplasm. The most common shape of the bivalents is X- or ring-shape, one or two chiasmata being present. In anaphase eleven daughter-chromosomes are distributed for each pole. On the way to the pole, each daughter-chromosome takes tetrapodal shape by the separating of the chromatids (Pl. XIII, fig. 11). In the nucleus of the interkinesis two nucleoli are found (Pl. XIII, fig. 13). After the second division of the meiosis four nuclei are formed, and then cell walls between each nuclei are laid down simultaneously. The cells in a tetrad dispose, in most cases, in tetrahedral fashion (Pl. XIII, fig. 15). After the dissolution of a tetrad, each cell is found in spherical or ellipsoidal shape (Pl. XIII, fig. 16). The microspore has one nucleus at first, but shortly before the shedding, in the latter part of March, the nucleus divides to form a pollen tube- and an antheridial nucleus (Text-fig. 1, a, b). Between these two nuclei a delicate membrane is formed ; a large and a small cell are thus formed. The small cell is an antheridial cell (Text-fig. 1, c). The matured pollen grain is spherical in a wet, and irregularly wrinkled in a dry condition ; the germ-pore is not present on the surface. The extine of the pollen grain is a thin and light brown layer with a granular surface. The intine is very thick and is formed of two layers. The outer layer of the intine is KÜHRWEIN's " Quellschicht " which swells in a wet condition. The inner layer of the intine is very delicate. These three layers, the extine and the two layers of the intine, are easily distinguished by the following means. If the pollen grain is immersed in diluted water solution of eosin or ruthenium red, the " Quellschicht " is swollen and the three layers of the wall

become visible. If we wish to see them more clearly a slight pressure on the cover glass is very effective.
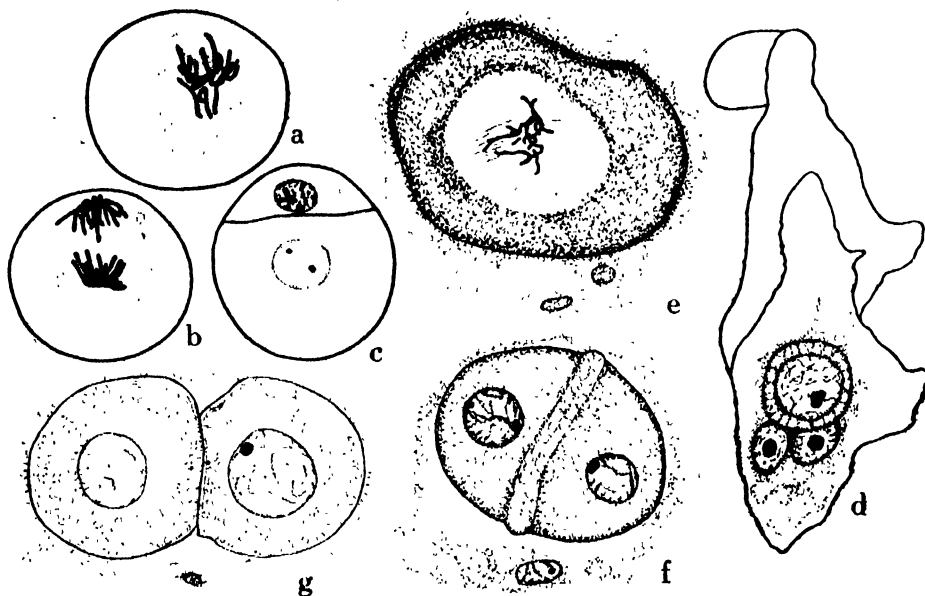
Text-fig. 1. a, Metaphase of the first division in a microspore. b, Anaphase of the same. c, Pollen; the large cell is the pollen tube, and the small cell is the antheridial cell. d, Pollen tube; somewhat elongated at the tip of a nucellus. The body-cell lies just behind two small nuclei which are the stalk- and the pollen tube-nucleus. e, Mitosis of the body cell to form the sperm cells. f, Telophase of the same. g, Two sperm cells in a pollen tube. a–c, ×1070. d–g, ×540.

The pollination takes place from late March to early April. The pollen grain is in two celled stage. At the time of pollination, the female gametophyte has only a few free nuclei.

Soon after the pollen grain has reached the nucellar tip, the elongation of the pollen tube takes place, and the antheridial nucleus in the male gametophyte divides to form a body cell and a stalk cell.

The body cell gradually increases in size, and the pollen tube- and stalk-nucleus become almost equal in size and cannot be distinguished from each other (Text-fig. 1, d).

The mitosis of the body cell takes place at about the same time as the division of the central nucleus of the archegonium, in the early part of June (Text-fig. 1, e). As a result of the division of the body cell,

two sperm cells are formed which are exactly alike in size and structure, and both have the function of fertilizing the egg (Text-fig. 1, f, g).

MEGASPOROGENESIS AND FEMALE GAMETOPHYTE

The archesporial cells differentiate at the same level of the insertion point of the integument to the nucellus. From one to several archesporial cells are found in each nucellus (Text-fig. 2). One cell in the group contains, however, more abundant granular substance in the cytoplasm than the others, and becomes the functional megaspore mother-cell, and the other archesporial cells become the tapetal cells. According to COKER's description ('04), the megaspore mother-cell of *Thuja* lies at right angle to the long axis of the nucellus, but in *Thujopsis* the long axis of the megaspore mother-cell agrees always with the long axis of the nucellus.
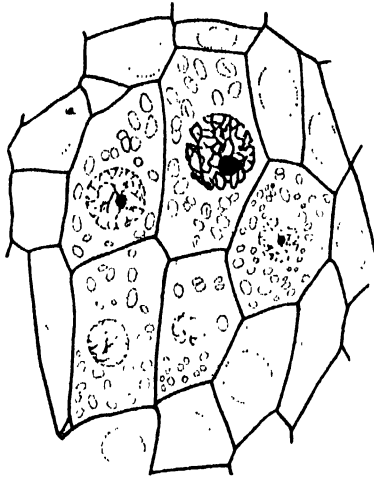
Text-fig. 2. A group of archesporial cells in a nucellus. One of the cells differentiates as a megaspore mother-cell, the nucleus of which is found in the pachytene stage of meiosis. × 640.

The meiosis of the megaspore mother-cell takes place from the latter part of December to the beginning of January (Text-fig. 3), consequently earlier than the meiosis of the pollen mother-cell, which takes place in the middle of February. As far as the writer is aware no similar instance of such early meiosis of the megaspore mother-cells has been noted up to the present in other conifers. But it must be noted that even in *Thujopsis* very occasionally the meiosis of the megaspore mother-cell takes place as late as the first half of April. After the first division of the meiosis a small upper cell and a large under cell are formed. The small upper cell sub-divides no more. The large under cell carries out the second division of the meiosis.

As the result of the meiosis, three cells are thus formed, and they are disposed in a row (Text-fig. 3, g). The two upper cells disintegrate later, and the lowest one becomes the functional megaspore. This manner of megaspore formation is noticed in *Cryptomeria* (KURIHARA '35), *Cun-*
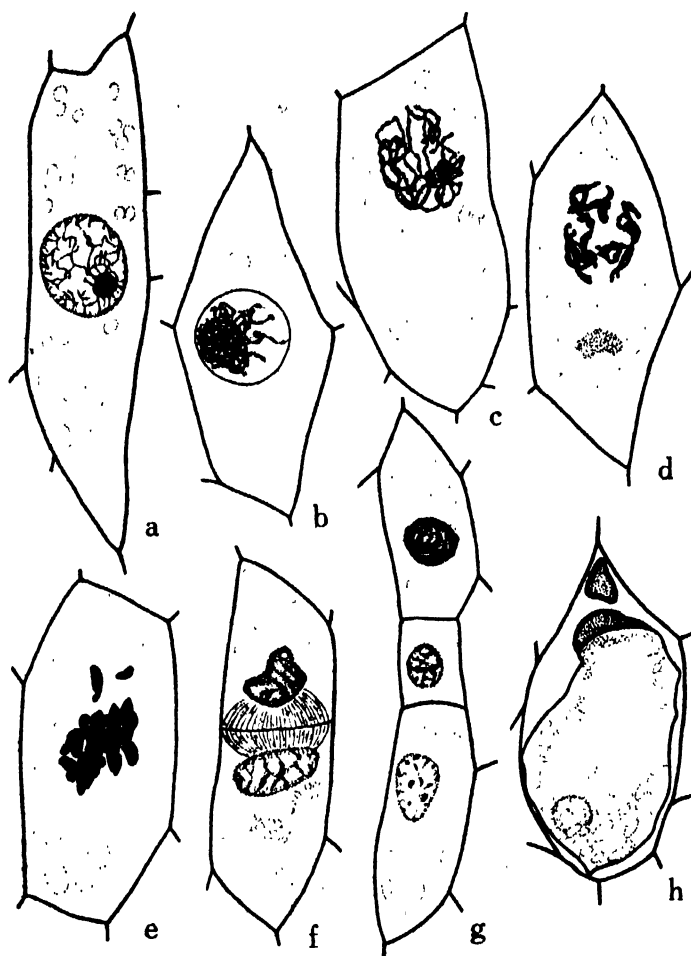
Text-fig. 3. Meiosis of the megaspore mother-cell. ×1070. a, Leptotene stage. b, Zygotene stage (Synizesis). c, Pachytene stage. d, Diplotene stage. e, Metaphase, I. f, Telophase, I. g, Triad; the upper cell formed by the first division divides no more. h, Early stage of female prothallium. The two degenerating cells are seen in the upper part of the prothallium.

ninghamia (MIYAKE '10), *Taxodium* (COKER '03) and others. The female prothallium is at first in a free nuclear condition which continues until the latter part of May, so the interval between the formation of the megaspore and the wall-formation of the female prothallium is about five months (Text-fig. 4, a). Mitoses of the free nuclei are in their early stages synchronic, but later, in some cases, slight differences are seen between the

apex and the basal region of the prothallium. The parietal layer of the
alveolar cells is formed in the usual manner (Text-fig. 4, b). The trans-
versal division of the alveolar cell is not found until the central vacuole
becomes filled up with tissue by the centripetal growth of the alveolar
cells (Text-fig. 4, c).
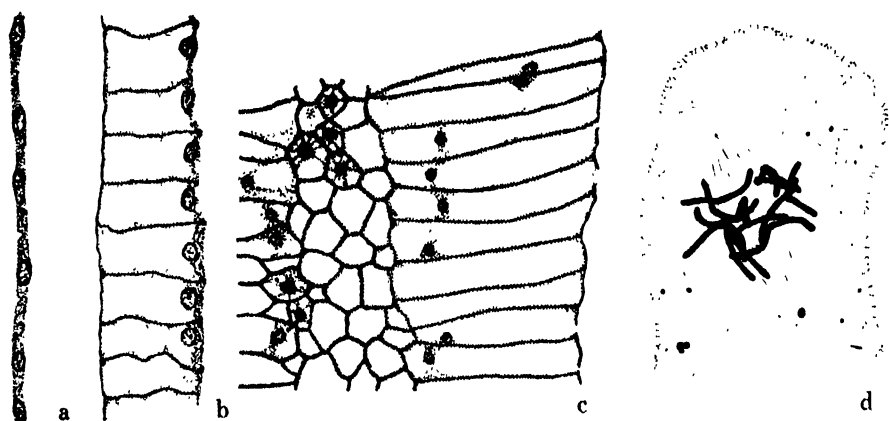
Text-fig. 4. a, Parietal layer of the free nuclei in a female prothallium. ×270.
b, Early stage of wall formation in the female prothallium. ×270. c, Alveolar cells
reached the axial line of the endosperm. ×150. d, Division of the central nucleus
of the archegonium. ×850.

Archegonial initials are grouped together in a complex at the apex
of the prothallium, and each initial is wedge-shape. At the outside of
the archegonial complex a single layer of jacket cells is found, but in
some cases, two or three layers are formed in a part of the tissue. The
archegonia of a complex vary in number from five to twelve, seven to
nine being the most common numbers. In the cell of the jacket layer,
mitosis was found at about the same time as the division of the central
nucleus of the archegonium. In the mitosis of the jacket cell, the
chromosomes can be counted with ease. The tapetal cells are at first
uninuclear, but after fertilization, some of them become binuclear and
go later into degeneration. The central vacuole of the archegonium is
at first very large but at about the time of the mitosis of the central
nucleus, the cytoplasm of the archegonium becomes very thick and many
proteid vacuoles appear. The proteid vacuoles are very small and are
not distinctive, and gradually disappear when fertilization takes place.
The neck-cells of an archegonium are arranged, in most cases, in a tier
of eight cells. Shortly before fertilization the division of the central

nucleus occurs. In the division, the number of the chromosomes was counted as eleven (Text-fig. 4, d). The ventral canal nucleus lies in the upper lateral side of the archegonium and is smaller than the egg nucleus.

The egg nucleus is very large and contains numerous spherical nucleolar bodies. These bodies are seen also in the archegonial initial- and central-nuclei, but they are aggregated in one or two groups. These granules in the egg nucleus, in some cases, are more than forty in number. But when fertilization occurs they decrease in number.

FERTILIZATION AND EMBRYOGENY

The fertilization takes place in early June, so the interval between the pollination and the fertilization is about two months.

By the breakage of the apex of the pollen tube which reaches an archegonial cavity, the sperm cells are discharged into the archegonial cavity. Each sperm cell from a pollen tube is able to fertilize an archegonium in the complex. At the time of the entrance of a sperm cell, other nuclei from the pollen tube in some cases also enter the archegonium. If additional nuclei are present, they are always found in the upper part of the archego-nium (Text-fig. 5, a). Sometimes mitosis of these additional nuclei is also found.

In *Chamaecyparis pisifera* (SUGI-HARA '38), *Thuja occidentalis* (LAND '02) or *Thuja orientalis* (LAWSON '07), the sperm nucleus which has entered the archegonium escapes from its own cytoplasm and moves towards the egg nucleus, but in *Thujopsis* the sperm nucleus moves towards the egg nucleus with its own cytoplasm (Pl. XIV, fig. 17). The contact of the male and the female nucleus takes place at the upper part of the archegonium.
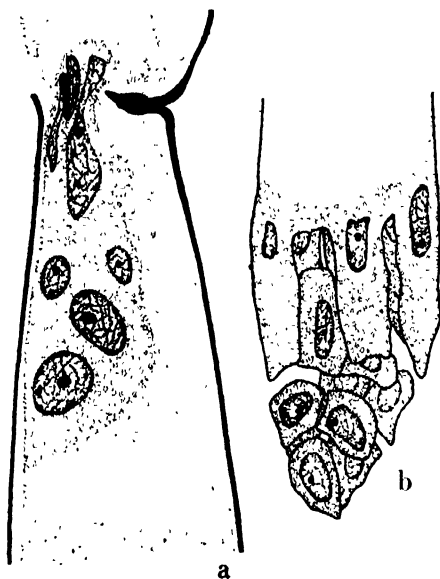
Text-fig. 5. a, Entrance of additional nuclei into an archegonium, which contains already a proembryo. ×470. b, Abnormal proembryo; the upper tier is formed by seven cells and the lower tier is formed by nine cells. ×470.

The female nucleus is clearly larger than the male nucleus (Pl. XIV, fig. 18). They are gradually wrapped in the coarse granular cytoplasm which originated from the sperm cell and pass down towards the bottom of the archegonium. The first mitosis after fertilization occurs at middle of the archegonium or slightly lower (Pl. X, fig. 19), just as in *Thuja occidentalis* (LAND '02). The spiremes of the male and the female nucleus remain distinct in the early stages of this mitosis (Pl. XIV, fig. 19). Such a case in Cupressaceae is known in *Juniperus commnis* var. *depressa* (NICHOLS '10). The spindle of this mitosis is intranuclear in origin and varies in its orientation. After the first mitosis the cell wall between the daughter nuclei is not formed. These two free nuclei with the cytoplasmic sheath reach the archegonial bottom and another simultaneous free nuclear division occurs there. The resulting four free nuclei are disposed in three different ways according to the dimension of the archegonium : 1) in a single row parallel to the long axis of the archegonium, 2) in two tiers, three nuclei in the upper, and one in the lower tier, 3) also in two tiers but each tier containing two nuclei.

The third mitosis is carried out also synchronously (Pl. XIV, figs. 20-21). The eight nuclei are now arranged in two tiers, the upper one of which contains six, five, or four nuclei. After this nuclear division the wall formation takes place, so the proembryonal free nuclear condition ceases at the stage of four nuclei. We have then eight cells arranged in two tiers; the cells of the upper tier are always open above (Pl. XIV, fig. 22). In the next stadium the upper tier divides into two layers (Pl. XIV, fig. 23), so three tiers are formed, the cells of the uppermost tier also remaining open to the general cytoplasm of the archegonium. The uppermost tier degenerates at a later stage, while the second becomes the prosuspensor and the lowest forms the embryo proper and the embryonal tube (Pl. XIV, fig. 24).

According to KAPFER ('35), the lowest tier is always formed by four cells, three of which lie in contact with the second tier, the fourth one being situated at the apex. But according to the writer's observation the lowest tier is not always formed by four cells; in some cases only two or three cells are found in this tier, and in the case, where four cells form the lowest tier, the arrangement of the cells are variable.

The cells of the lowest tier, in most cases, sub-divide once before the prosuspensor elongates. Each of them has the ability to form an embryo independently, that is, they are embryonic initials in nature. This is clearly seen, when the prosuspensor is elongated. Several embryonic

units are then formed independently at the apex of the prosuspensor (Pl. XV, figs. 25–27). This description of the conditions at this stage differs from KAPFER's ('35); he states that the lowest tier of the proembryo is formed by four cells, three of which are in contact with the second tier, and that the fourth one lies at the apex forming an apical cell, only one embryo being formed by the sub-divisions of this cell. Cleavage polyembryony was also denied by him to exist in this species.

It seems probable that each embryonic unit may have the ability to form an embryo independently, but in reality only the one situated at the apex of the group grows larger, while the others are prevented from growing and become later the embryonal tubes (Pl. XV, figs. 28-30). In some cases, however, two or more embryos are formed at the tip of a prosuspensor (Pl. XV, fig. 31).

Some of the prosuspensor cells are sometimes found separated from the principal portion of the embryo without having any embryonic cell. They form irregular shaped embryos which correspond to the rosette embryos found in *Pinus* (Pl. XV, figs. 33–35).

In conclusion, in the embryo system of *Thujopsis dolabrata* the open cell, the prosuspensor, the embryonal tube and the embryo proper are found, but not the primary suspensor can be seen. In some cases, cleavage polyembryony and rosette embryos are also found. Simple polyembryony is also frequently found (Text-fig. 6).

The embryo proper in the later stage gradually increases in size and differentiates in many organs, and the typically dicotyledonous embryo is formed (Pl. XV, fig. 32).
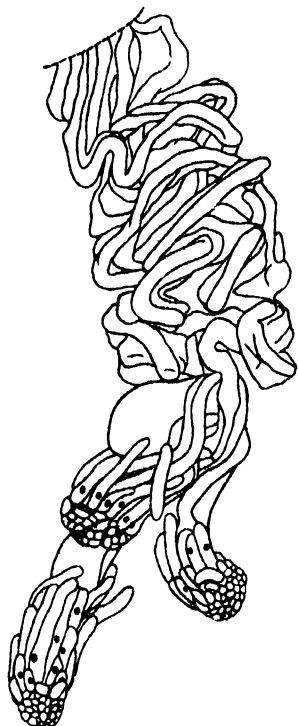
Text-fig. 6. Simple polyembryony; a complex of three embryos. ×50.

ABNORMALITY

1) *Thujopsis* is a monoecious plant and forms two sorts of cone, male and female, on a tree. In the middle of April 1937, writer obtained

an abnormal bisexual cone. It bears several pollen sacs in the basal scales and several ovules in the apical scales. In the scales of the intermediate position several pollen sacs and irregular masses of tissue are seen. The gametophyte of the ovules from the apical scale are found in free nuclear condition, and in the pollen grains of the pollen sacs from the basal or intermediate position of the cone, one or two nuclei are found.

2) Two nucellus in an integument were sometimes found. As far as the writer is aware, similar cases have been found in *Cryptomeria japonica* (LAWSON '04) and in *Thuja orientalis* (COKER '04).

3) In several cases, two prothallia in a nucellus were found. Each prothallium was found in free nuclear condition, and they were almost equal in size. It is not clear whether these two prothallia have originated from a single or from two megaspore mother-cells.

4) In one case sixteen cells of an embryo are found in two tiers the upper tier being formed by seven cells, and the lower by nine cells (Text-fig. 5, b).

SUMMARY

1) In *Thujopsis dolabrata* var. *Hondai*, meiosis of the pollen mother-cells takes place in the middle of February.

2) In the metaphase of the first division of the meiosis eleven bivalents are clearly counted.

3) The mature pollen grain is in two cells, the outer wall consisting of three layers.

4) The two sperm cells which are formed by the division of a body cell are equal in size and structure and are both functional.

5) Several archesporial cells become differentiated in a nucellus. But only one of them differentiates as a megaspore mother-cell, the others becoming tapetal cells.

6) Meiosis of the megaspore mother-cell takes place from the latter part of December to early January. Consequently, it occurs earlier than that of the pollen mother-cells.

7) As a result of meiosis of the megaspore mother-cell three cells are formed. The lowest one of which is the functional megaspore.

8) The female prothallium contains at first only free nuclei. The transversal divisions of alveolar cells does not occur, until they meet in an axial line of the endosperm.

9) The archegonia are grouped together in a complex at the apex of the endosperm. The complex, in most cases, is surrounded by a single layer of jacket cells. In the mitoses of these jacket cells eleven chromosomes are easily counted.

10) The most usual number of the archegonia in a complex is seven to nine.

11) The neck cells of an archegonium, are arranged usually in a tier of eight cells.

12) In the division of the central nucleus, eleven chromosomes are clearly counted.

13) The fertilization occurs in early June. The contact of the male and the female nucleus takes place at upper part of the archegonium.

14) The first mitosis after the fertilization occurs at the middle portion of the archegonium or slightly lower.

15) In the first mitosis, the spiremes of the male and the female nucleus are distinct; the spindle is intranuclear in origin.

16) Free nuclear stage of the proembryo ceases at the stage of four nuclei.

17) The embryo consists of the open cells, the prosuspensor, the embryonal tube and the embryo proper.

18) The primary suspensor is not found.

19) Sometimes a tendency to cleavage polyembryony is found.

20) In some cases, the irregular rosette embryos are also found.

21) Simple polyembryony always occurs.

22) The embryo is dicotyledonous.

23) Several abnormalities are described.

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EXPLANATION OF PLATES

PLATE XIII

Meiosis of the pollen mother-cells. × 1250.

Fig. 1. Pollen mother-cell in the resting stage.
Fig. 2. Leptotene stage.
Fig. 3. Zygotene stage.
Fig. 4. Pachytene stage.
Fig. 5. Early diplotene stage.
Fig. 6. Late diplotene stage.
Figs. 7–8. Diakinesis.
Fig. 9. Metaphase, I. in polar view.
Fig. 10. The same in side view.
Fig. 11. Anaphase.
Fig. 12. Telophase.
Fig. 13. Interkinesis.
Fig. 14. Anaphase, II.
Fig. 15. Tetrad.
Fig. 16. Microspore in uninucleate condition.

PLATE XIV

Fertilization and Proembryogeny. × 630.

Fig. 17. Male and female nuclei in an archegonium.
Fig. 18. Nuclei in fertilization.
Fig. 19. Prophase of proembryonal first division. The spiremes are found in two groups.
Fig. 20. Proembryonal third division; such a disposition of four spindles is very rare.
Fig. 21. Proembryonal third division; four spindles in tetrahedral disposition.
Fig. 22. Eight nucleus stage after wall formation.
Fig. 23. Mitosis in the upper tier.
Fig. 24. Early stage of prosuspensor elongation.

PLATE XV

Embryogeny.

Fig. 25. Early stage of prosuspensor elongation. Four embryo systems are found. ×100.

Fig. 26. More advanced stage of prosuspensor elongation. ×100.

Fig. 27. A group of the embryonic units at the tip of a prosuspensor. ×220.

Fig. 28. More advanced stage of the development of an embryonic tier. ×220.

Fig. 29. Early stage of the elongation of the embryonal tube. ×220.

Fig. 30. A tendency to a cleavage polyembryony. The basal embryonic units are elongated as the embryonal tube, but some of them are not yet elongated. ×100.

Fig. 31. Cleavage polyembryony; three embryos are formed at the tip of a prosuspensor. ×100.

Fig. 32. More advanced stage of embryo formation; shrunk prosuspensor and elongating embryonal tube. ×70.

Figs. 33-35. Rosette embryo. ×100.
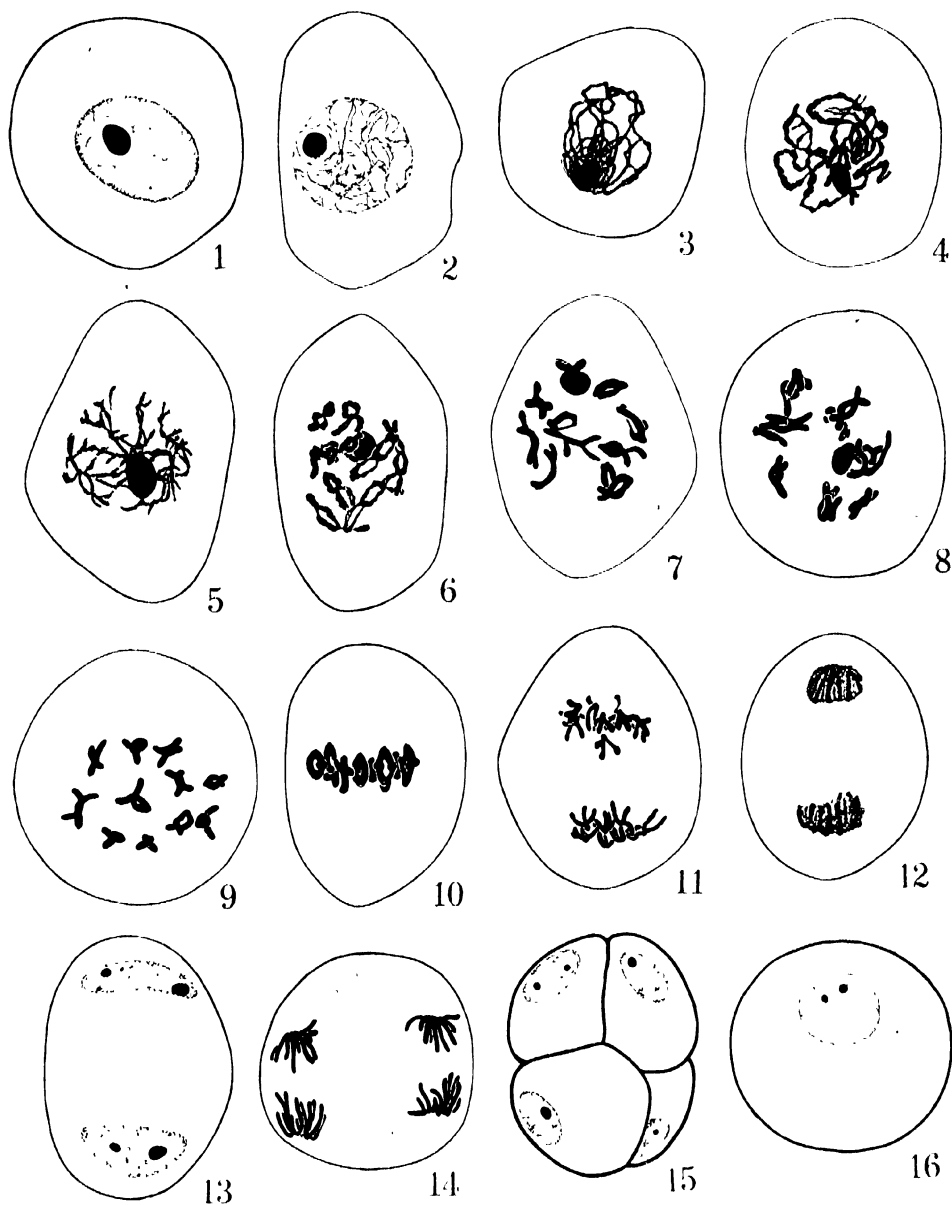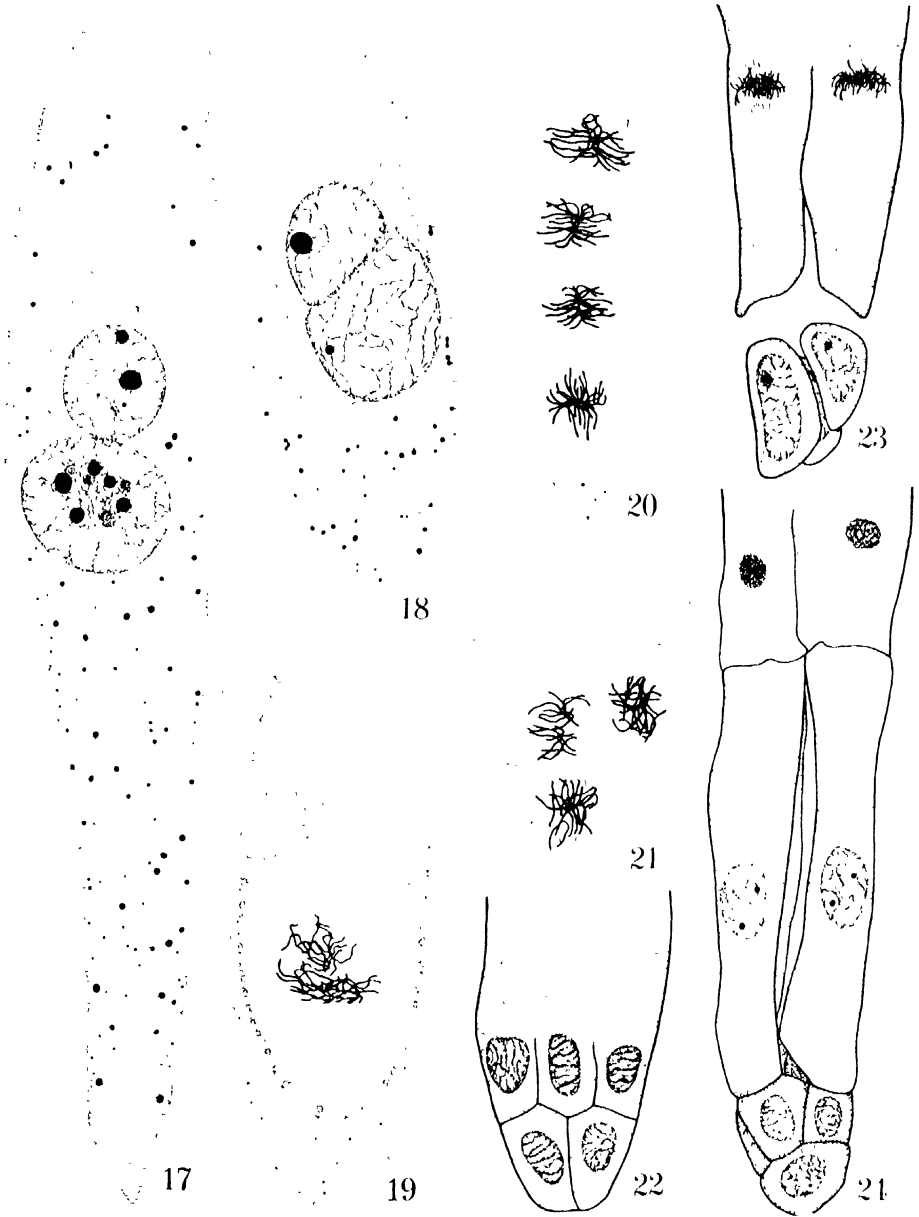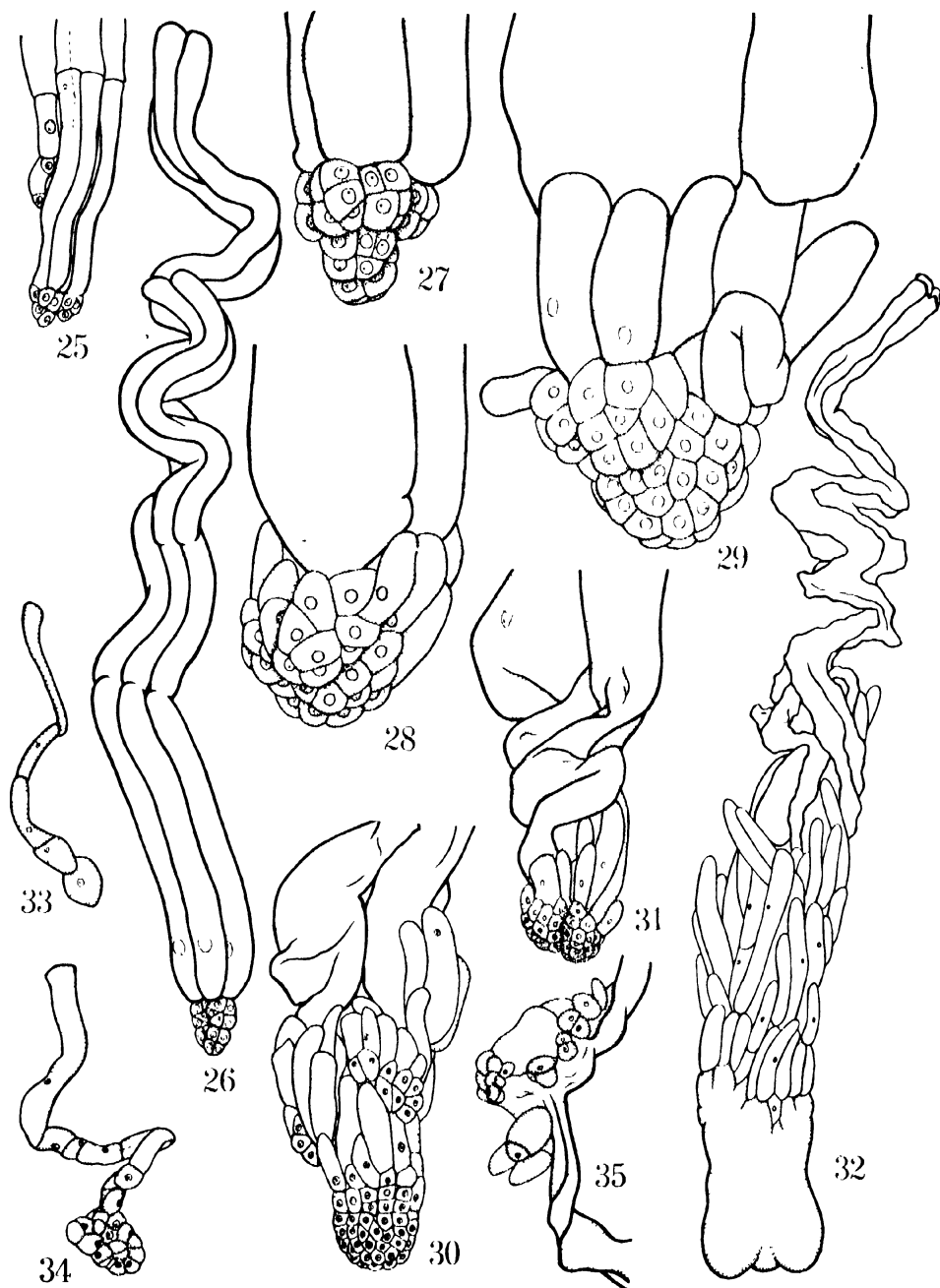
A REPORT OF OBSERVATIONS MADE OF THE EGG-FOLLICLE FORMATION IN THE CASE OF *CYNTHIA RORETZI* DRASCHE

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(With Plate XVI and 7 text-figures)

(Received June 8, 1939)

Generally speaking, each mature ovarian egg of the ascidians is surrounded, at the commencement of its development, by a complicated system of envelopes, and it has been one of the problems in studying the ascidian egg to trace the origin and fate of these envelopes. HERDMAN (1899) maintained that altogether there may be distinguished as many as seven layers around the mature egg. With regard to *Cynthia roretzi*, however, five envelopes only are discernable. They are as follows, reckoning them in sequence from the outside to the inside (Text-fig. 1):—

I. The basement membrane
II. The outer envelope
III. The inner envelope
IV. The chorion
V. The layer of test-cells

The problem of the origin and the fate of the envelopes has long been discussed by many authorities, the present writer also wishes to join them by describing the results of his observations.

. Before proceeding further, the present writer wishes to express his sincere thanks to Prof. Dr. EKITARO NOMURA, who gave him this interesting thema, and under whose kind direction and encouragement his investigations have progressed. He is also greatly indebted to Mr. K. OKADA
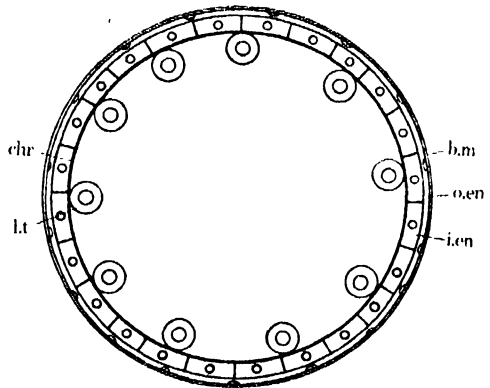
Text-fig. 1. Diagrammatic representation of the mature ovarian egg of *Cynthia roretzi* DRASCHE, showing the five envelopes. *b.m* basement membrane, *chr* chorion, *i.en* inner envelope, *l.t* layer of test-cells, *o.en* outer envelope.

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and Mr. I. HAMAI of the laboratory, and to the courteous officials of the Fisheries Experimental Station, Kesennuma, Miyagi Prefecture, for the kind assistance given him during the course of this study. Furthermore, he desires to take this opportunity to thank Mr. TORIMATSU HATAKEYAMA, Hinatagai, Karakuwamura, Motoyosi District, Miyagi Prefecture, who is culturing a great abundance of *Cynthia roretzi* for the purpose of food, and who was not miserly in supplying him with abundant materials and in giving him every kind consideration.

MATERIAL AND METHOD

The material used in the present study was a quantity of the ovaries of *Cynthia roretzi* DRASCHE, which was collected in January, March, April, May, July, September and October, 1937, at the Sea-squirt Breeding Station of Mr. HATAKEYAMA.

According to Dr. ASAJIRO OKA, the range of the distribution of *Cynthia roretzi* extends from Hokkaidô southwards to Sikoku and Kyûsyû, but the southern limit of its abundant occurrence seems to lie somewhere near the Ozika Peninsula, Miyagi Prefecture, on the Pacific coast, and near the Oga Peninsula, Akita Prefecture, on the Japan Sea coast.

When collecting the specimens, the ovaries were removed from the living individuals and were fixed by various methods. The fixed materials were then sectioned serially, 5μ or 10μ in thickness, by the paraffin method. After sectioning, the objects were stained by several staining methods. It was eventually agreed that fixation with Bouin's solution, and staining by Mallory's connective tissue staining method were respectively the most suitable methods for the purposes of the investigation. There-fore, this combination of the fixation and the staining was used in every case of the present study.

As the maturing of the egg depends upon season and age, a series of suitable samples at every stage of the oögenesis were not obtainable throughout the year. The present writer, however, found the month of July the most suitable season for the present investigation. So, he carried out his investigation chiefly using materials removed in July from adult specimens, which had passed three winters after the attachment of the larvae.

OBSERVATION

The Movement of the Oögonium from the Germinal Epithelium to the Stroma of the Ovary

The oögonium in the germinal epithelium is distinguishable by being of a larger size than the other cells, and it is surrounded by several follicle cells which are usually considered to be abortive eggs (Text-fig. 2). The oögonium at this stage has no membrane around it, with the exception of the primary egg membrane, which is very thin and stainable with acid fuchsin. The oöplasm stains feebly and uniformly with orange G. It contains microsomes assembling here and there at random, which take a mixed stain of acid fuchsin and aniline blue. The nucleus is very large in relation to the size of the cell body, and contains thick thread-like chromatins, which stain in the same way as the microsomes. The nucleolus is large and takes the stain of orange G (Text-fig. 2).

Text-fig. 2. An oögonium in the germinal epithelium, showing the relation between it and its follicle cells. f.c follicle cells surrounding the oögonium, g.ep germinal epithelium, o oögonium, st stroma of the ovary. ×450.

The oögonia in the germinal epithelium continue their growth and then begin to move to the general stroma of the ovary. At the beginning of the movement, each oögonium pushes out the basement membrane of the germinal epithelium, and, finally, this protruded surface of the oögonium becomes covered by a stretched, thin basement membrane.

It was at this stage, in which the oögonia begin to move from the germinal epithelium to the general stroma of the ovary, that the writer was able to find the follicle cells differentiating into two kinds (Text-fig. 3). The follicle cells, fusiform originally, change either into a slender shape (Text-fig. 3 and Pl. XVI, Figs. 1 and 2, o.f), or into a globular shape (Text-fig. 3 and Pl. XVI, Figs. 1 and 2, i.f). The cytoplasm of the slender cells stains with aniline blue as much as does that of the cells of the germinal epithelium, but the cytoplasm of the globular cells is transparent and nearly unstainable. The nuclei of the former are ovoid and contain a smaller number of thin chromatins than do the nuclei of the cells constituting the germinal epithelium, while those of the latter are spherical and contain a larger number of stout chromatins which stain accurately with acid fuchsin. In tracing their development from an earlier stage to a later, it was ascertained that the slender cells constitute the outer

follicular, and the globular ones the inner follicular epithelium.

It is noticeable that, with the progress of the growth, both kinds of follicle cells bring pressure upon the oöplasm, but, in general, the slender outer ones press the oöplasm slightly, while the globular inner ones press it so strongly, that concavities are indented on the faces of the vitelline membrane that are in contact with the cells (Text-fig. 3 and Pl. XVI, Figs. 1 and 2).

The oögonium at this stage increases the quantity of microsomes. The thread-like microsomes distribute uniformly in the oöplasm which stains feebly with orange G. The nucleus measures about half the diameter of the oögonium. The chromatin threads become entangled in a complicated manner and, in some of the entangled meshes, are found irregularly shaped granules, which stain with orange G. The nucleolus involves a sphere, which touches internally. The former stains with orange G deeper than does the latter. Sometimes, the latter takes a deep stain of acid fuchsin (Text-fig. 3).
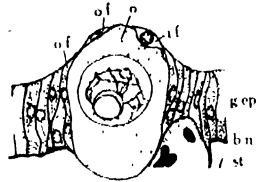
Text-fig. 3. A growing oögonium and its follicle cells, showing the commencement of their movement from the germinal epithelium to the stroma of the ovary, and the presence of two kinds of follicle cells. *b.m* basement membrane, *g.ep* germinal epithelium, *i.f* inner follicle cell, *o* oögonium, *o.f* outer follicle cell, *st* stroma of the ovary. ×450.

The Completion of the Movement of the Oögonia and the Formation of the Outer and Inner Follicular Epithelia

As its growth increases the oögonium, surrounded by the follicle cells, moves gradually from the germinal epithelium to the stroma of the ovary, through the stages shown in Text-figs. 3, 4 A, 4 B and 4 C in the order of the number. When it reaches the stage shown in Text-fig. 4 C, the movement is completed.

With the progress of the movement of the oögonium into the stroma, the outer and inner follicle cells increase in number. In the stages of Text-figs. 3 and 4 A, one or two inner follicle cells and about ten outer follicle cells were counted; in the stage of Text-fig. 4 B about seven inner follicle and about ten outer follicle cells; in the stage of Text-fig. 4 C about ten inner and about fifteen outer follicle cells; and in the stage of Text-fig. 4 D about thirty six inner and about forty outer cells were counted. In the stage of Text-fig. 4 D, the inner follicle cells were found forming

4A

4C

4B

4D

Text-fig. 4. An oögonium moving towards the stroma, showing its size and the number of the outer and inner follicle cells. The developmental stages progress in the order of A, B, C and D. In D, the section did not pass the follicle style. *b.m* basement membrane, *f.st* follicle style, *g.ep* germinal epithelium, *g.ep.c* germinal epithelial cell, *hy.p* hyaline cytoplasm, *i.f* inner follicle cell, *i.v.b* intra-vitelline body, *o.f* outer follicle cell, *y.g* yolk granule. ×450.

groups here and there on the outer surface of the oögonium. In the stage of Text-fig. 5, the outer follicle cells were arranged already in the outer follicular epithelium and the inner ones in the inner follicular epithelium.

With the progress of the stages, the thread-like microsomes, which continue in taking a mixed stain of acid fuchsin and aniline blue, increase gradually in number and quantity and become distributed densely in the oöplasm.

While each oögonium is moving towards the stroma, one or two irregularly shaped masses begin to be observed in the oöplasm near the nucleus. They take a mixed stain of deep acid fuchsin and aniline blue. The writer wishes to call them the ' intra-vitelline bodies.' These bodies increase gradually in number and finally become distributed hither and thither in the oöplasm. In general, the intra-vitelline bodies are larger in the positions near the nucleus and smaller towards the periphery of

the oöplasm. Meanwhile, some hyaline portions begin to appear in the oöplasm, sometimes surrounding one or two intra-vitelline bodies. Presently, some yolk granules, which are stainable with aniline blue, begin to appear in each of the hyaline portions. The yolk granules increase gradually in size and number and, finally, the oöplasm becomes filled with them, with the exception of its peripheral zone. The intra-vitelline bodies deminish in size, apparently, with the increase of the yolk granules in size and number. As a matter of fact, when the oöplasm is filled with yolk granules, the intra-vitelline bodies completely disappear.

Text-fig. 5. An oögonium, showing its contents and envelopes. The boundary between the outer and inner follicular epithelia was not observable. *i.f* inner follicular epithelium. *o.f* outer follicular epithelium. × 450.

At the time of the appearance of the intra-vitelline bodies, the microsomes show affinity to acid fuchsin more than aniline blue. The chromatin threads in the nucleus entangle more compactly, and they take the same stain as the microsomes. Some globules, which are stainable with orange G, are now observed attached to some of the chromatin threads and, at the same time, some transparent spheres appear in the nucleolus, which stains with orange G. Besides this nucleolus, sometimes, a nucleolus-like sphere is found in the same nucleus. The sphere involves several granules. It takes, as a whole, the mixed stain of deep acid fuchsin and aniline blue similarly to the chromatins as well as the microsomes, but the granules stain feebler than the sphere.

The Establishment of the Follicle Style

At the time of the complete separation of the oögonium from the germinal epithelium, the outer follicle cells, which remained in the germinal epithelium to the last of the movement of the oögonium, become some-

what elongated, and connect some cells of the germinal epithelium with the outer follicular epithelium of the oögonium at its end just detached from the germinal epithelium. This portion of the outer follicle, including some cells of the germinal epithelium and of the inner follicle, constitutes the so-called follicle style (Text-figs. 4 B and 4 D, *f.st*). In the case of *Cynthia roretzi*, this style is considerably short in comparison with those in the cases of other ascidian species.

The Appearance of the Test-cells

After the complete formation of the follicular epithelia, some cells are found beginning to protrude towards the oögonium at all sides of the inner follicular epithelium. In this stage, the structure of these protruding cells is seemingly identical to that of the inner follicle cells (Text-fig. 6, *t.c* and Pl. XVI, Fig. 3, *t.c*). These cells gradually encroach in the oögonium and become finally attached with one end on the original epithelium, the main cell-bodies being embedded in the peripheral zone of the oöplasm. In a word, some cells intercalated in the inner follicular epithelium are translocated from this epithelium to the outer zone of the oögonium. They are the test-cells (Text-fig. 6, *t.c*).

At the time of the complete differentiation of the test-cells, a very thin membrane, which takes the stain of aniline blue,
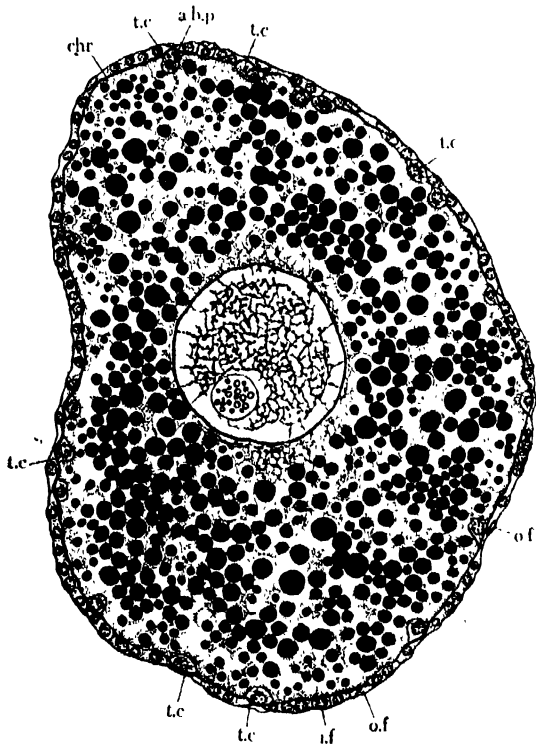
Text-fig. 6. A later, grown oögonium, showing its contents and the formation of the test-cells and of the chorion. *a.b.p* cytoplasm of the test-cell which is stainable by aniline blue, *chr* chorion, *i.f* inner follicular epithelium, *o.f* outer follicular epithelium, *t.c* test-cell. ×450.

appears between the inner follicular epithelium and the vitelline membrane, and the test-cells become enclosed inside this thin membrane (Text-fig. 6, *chr*). This new membrane is the origination of the chorion and henceforth it gradually increases in thickness. Up to this time, the vitelline membrane was stainable by acid fuchsin. The chorion and the vitelline membrane, thus, were accurately distinguishable by the different colour. The red colour of the vitelline membrane attached to the chorion, however, fades gradually and becomes replaced by the blue colour of the chorion.

At the time of the appearance of the chorion, a small irregular portion, which stains by aniline blue as intensely as the chorion, is observable in the cytoplasm of each test-cell (Text-fig. 6, *a.b.p*). The same phenomenon is seen also in each cell constituting the inner follicular epithelium.

Through the stages of the formation of the chorion, the inner follicular epithelium gradually increases in thickness, and the cell-boundaries between the component cells become distinct. But the outer follicular epithelium always retains its thin flatness.

The Structure of the Egg Approaching Maturation

The ovarian egg is round measuring about 230 μ in diameter and consists of an oögonium and five envelopes.

The oögonium contains yolk granules, which take the stain of aniline blue, and finely granular microsomes, which take the mixed stain of acid fuchsin and weak aniline blue.

The yolk granules are of different sizes, viz. 6-7 μ in largest diameter and 2-3 μ in smallest. They are distributed all over the oöplasm, with the exceptions of a part surrounding the nucleus and a zone of nearly 15 μ thick at the periphery of the oögonium (Text-fig. 7, *y.g*). The microsomes are very fine and are of the same size. They are usually arranged in threads, which entangle with each other, and are distributed all over the oöplasm, especially densely in the peripheral zone of the oögonium (Text-fig. 7, *ms*).

The nuclear membrane of the germinal vesicle is thin and takes a stain of acid fuchsin. It involves entangled thread-like chromatins which stain with acid fuchsin. The nucleolus consists of two parts, viz. one is a globule which stains with acid fuchsin and which is located excentrically in the nucleolus, and the other takes orange G and surrounds the globule, containing small bubble-like spheres. Sometimes, two or three bubble-like spheres are seen outside the nucleolus (Text-fig. 7, *N, n*).

The egg-covering consists of the following five layers : —

1) The basement membrane. This layer cannot be distinguished from the outer follicular epithelium, the second layer of the egg-covering. As has been mentioned already, however, the oögonium in the earlier stage was accurately pushing the basement membrane of the germinal epithelium, and the writer was able to observe neither its destruction nor any phenomena causing its disappearance. He believes, therefore, in the existence of the basement membrane on the outermost surface of the egg. even though it is stretched to an invisible thickness.

2) The outer follicular epithelium. The outer follicular epithelium is a very thin layer, being connected by the follicle style with the germinal epithelium of the ovary. It takes a stain of aniline blue. Each nucleus of the epithelium is flat measuring about 2 μ by 7 μ and contains chromatins, which are stainable by acid fuchsin. The nucleolus is hardly recognizable (Text-fig. 7, o.f).

3) The inner follicular epithelium. This is a thick unicellular layer, which adheres closely to the inner surface of the outer follicular epithelium. The cells of this epithelium are hexagonal when viewed from the outer side and measure about 10 μ in height and 15 μ in width, and each cell contains two kinds of cytoplasm, mixed irregularly, viz. one takes the stain of acid fuchsin and the other that of aniline blue. The nucleus is spherical showing 3 4 μ in diameter. The nucleolus is hardly detectable (Text-fig. 7 and Pl. XVI, Fig. 4, i.f).

4) The chorion. This is a structureless, non-cellular membrane of about 2 μ thick, lying just inside the inner follicular epithelium and enclosing directly the oögonium together with the test-cells. This layer is stainable by aniline blue (Text-fig. 7 and Pl. XVI, Fig. 4, chr).

5) The test-cells (Text-fig. 7 and Pl. XVI, Fig. 4, t.c). These cells do not make a complete cell-layer, but are found attached to the inner surface of the chorion and scattered irregularly, here and there, in the peripheral zone of the oögonium, which is furnished with abundant microsomes. Each test-cell is ellipsoidal, measuring about 10 μ in the shortest diameter and 14–15 μ in the longest. The longest axis of each cell is perpendicular to the chorion. The test-cell contains a spongy mass of cytoplasm, which is somewhat compactly formed. The nucleus is spherical, measuring about 4 μ in diameter and contains a network of chromatins. The nucleolus is hardly observable.
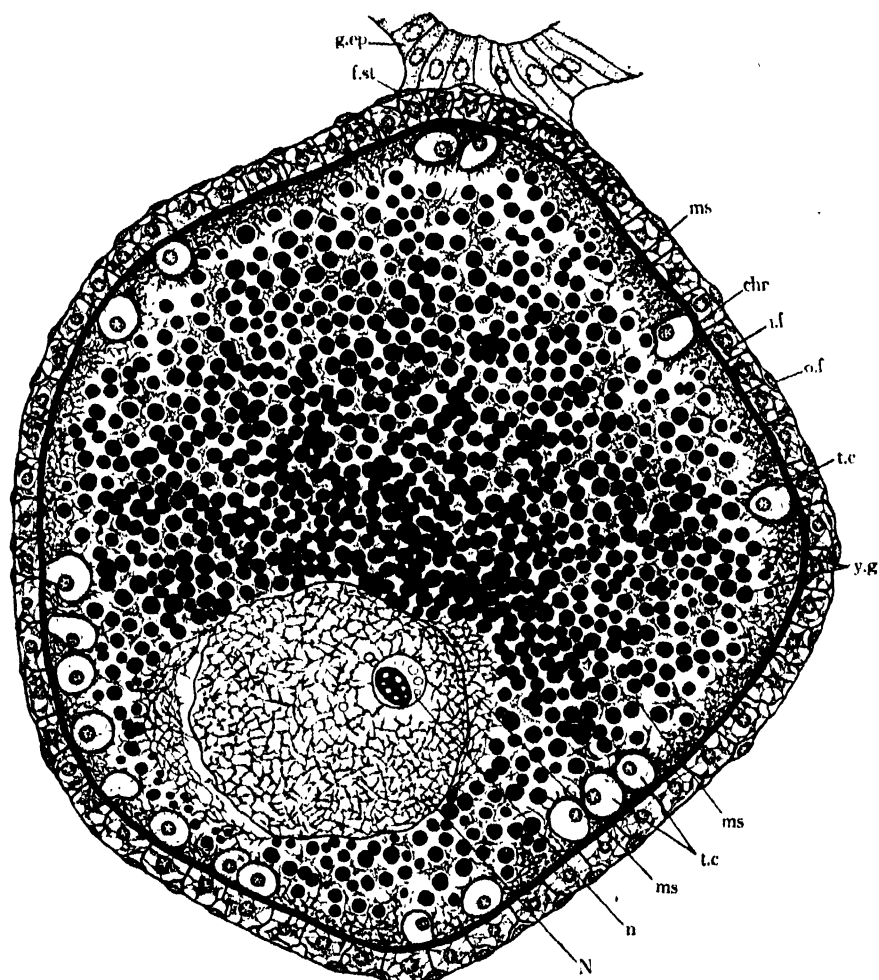
Text-fig. 7. An oögonium approaching maturation, showing its structure and envelopes. *chr* chorion, *f.st* follicle style, *g.ep* germinal epithelium, *i.f* inner follicular epithelium, *ms* microsomes, *N* nucleus, *n* nucleolus, *o.f* outer follicular epithelium, *t.c* test-cells, *y.g* yolk granules. ×450.

DISCUSSION

The Outer and Inner Follicular Epithelia

It is recognized already by many investigators that a young, ascidian oögonium in the germinal epithelium is surrounded by follicle cells, which are abortive eggs, and that these follicle cells constitute follicular epithelia.

"In sections through the ovary," states MORGAN (1891) in the case of
Cynthia ocellata, "nuclei are seen lying along the wall of the cavity of
the ovary ; and here and there one is seen to have enlarged, and the
protoplasm about it to have increased in quantity. This nucleus and
protoplasm form the commencement of a new egg.....At the periphery
of this young egg another nucleus is seen. This nucleus is one of those
peripherally lying nuclei which go to form the follicular nuclei of the
egg." He states further in the case of *Clavellina* sp. that "the young
nuclei of the ovum arise in the germinal epithelium of the ovary, and
are at first like the ordinary nuclei of the membrane.....A somewhat
older ovum is...., in which the protoplasm about the nucleus has in-
creased, and there is a sharper distinction between the egg proper and
the more peripherally lying follicular nuclei." "Die Follikelzellen," states
FLODERUS (1896) in the cases of *Ciona* sp., *Clavelina* sp., *Styela rustica,*
etc. "sind Anfangs nur wenig an der Zahl und liegen an der Peripherie
des Eies zerstreut, ohne deutliche Membranen weder nach aussen noch
nach innen gegen den Dotter, in dessen oberflächliche Schicht sie häufig
wie eingesenkt erscheinen. Nachher nehmen sie an Zahl zu, stellen eine
geschlossene Hülle um das Ei dar und sondern auf ihrer einwärts gegen
das Ei gekehrten Seite eine strukturlose Membran, das Chorion, auf ihrer
äusseren Seite eine ähnliche, die strukturlose äussere Follikelmembran, ab.
Etwas später treten zwischen den Follikelzellen in radialer Richtung deut-
liche Membranen hervor." In the case of *Cynthia roretzi,* the outer
structureless membrane of the follicle, which might be formed by the
follicular epithelia, is not observed, and it is also true that the follicle
cells which surround the early oögonium in the germinal epithelium form
the follicular epithelia which surround the grown oögonium.

Regarding the formation of outer and inner follicular epithelia, VAN
BENEDEN and JULIN (1887), PIZON (1893), FLODERUS (1896), SCHAXEL
(1910), etc. put forward the opinion, i. e. with the growth of an oögonium,
follicle cells which surround the oögonium form an epithelium and this
epithelium divides into outer and inner epithelia, when the oögonium
grows further. Against this, MORGAN (1891) put forward his opinion in
the case of *Clavellina* sp. that "outside of the membrane the columnal
follicular cells form a layer completely investing the egg, and beyond the
follicular cells in an imperfect layer formed of scattered cells which seen
to be derived from the inner substance of the ovary, although I have
not carefully traced their origin." In the case of *Cynthia roretzi,* there
have been found two kinds of follicle cells around the early oögonium,

and each kind forms the outer or inner follicular epithelium, respectively.

"Es ist mir gelungen," states FLODERUS (1896), "diese Zellenschicht bei einem grossen Theile der untersuchten Formen, wie z. B. bei *Ciona, Clavelina, Styela rustica, Corella parallelogramma* u. A. nachzuweisen. So findet man recht oft die Follikelkerne älterer Eier von *Styela rustica* zwischen dem Chorion und der äusseren strukturlosen Follikelmembran alternierend angeordnet, indem jeder zweite, mehr abgerundet, der ersteren Membran näher liegt — falls er nicht die ganze Breite zwischen den beiden Membranen einnimt — und die dazwischen liegenden, mehr ovalen und stärker abgeplatteten Kerne dicht an die äussere Membran gedrückt sind. Auf dem Schnitte ist dieses Verhalten nur in einem Theile oder an vereinzelten Stellen der Follikelhülle ausgeprägt, was jedoch leicht daraus erklärt wird, dass zwei benachbarte, alternierende Kerne oft auf zwei oder mehrere Schnitte vertheilt worden sind. Eine deutliche Membran zwischen diesen beiden Zellenschichten existirt jedoch in diesem Stadium nicht." He states further that "Nach der Bildung der Testazellen entsteht um das Ei noch eine dritte Hülle, nämlich das äussere Follikelepithel. Diese Schicht kommt dadurch zu Stande, dass das sekundäre Follikelepithel sich in zwei Schichten theilt, von denen die eine, mehr peripherisch liegende eben dieses äussere Follikelepithel ausmacht, während die innerhalb desselben gelegene das innere Follikelepithel bild. Die äussere Follikelhülle ist stark abgeplattet und liegt der äusseren strukturlosen Follikelmembran dicht an."

There is also another opinion which maintains that the outer follicular epithelium is formed by the cells' dividing towards the outside of the primary unicellular follicular epithelium, as stated by SCHAXEL (1910) in the cases of *Styela* sp.

The Test-cells

In the case of *Styela*, SCHAXEL (1910) states that the test-cells are formed by cell-division which has taken place in the follicular epithelium. In the case of *Cynthia roretzi*, however, neither the mitotic nor the amitotic figure, formed perpendicularly to the inner follicular epithelium, was observed. In the case of *Cynthia ocellata*, MORGAN (1891) states with regard to the origin of one test-cell that "one of the follicular cells has changed somewhat its position, and has come to lie a little interior to the cells of the follicular zone. The cell contains a nucleus which agrees in all details those of the follicle." A similar observation was carried out also in the case of *Cynthia roretzi*.

The Chorion

SEELIGER-HARTMEYER (1893-1911) state that the chorion, in the case of *Styela rustica*, etc., is formed before the test-cell formation and, in the case of *Ascidia mentula*, etc., after the test-cell formation. MORGAN (1891) states in the case of *Clavellina* that, when test-cells are pushed forwards inside the follicular zone, a membrane is found between the follicular cells and the yolk, and that this membrane is secreted or converted by a substance at the peripheral zone of oöplasm. SCHAXEL (1910) states in the cases of *Styela, Cynthia, Ciona* and *Ascidia* that the chorion is secreted from follicle cells at the stage of the test-cell formation.

In the case of *Cynthia roretzi*, as stated already in the chapter in this report designated " Observation ", the chorion is stainable with aniline blue and, when the test-cells are completely formed, it begins to appear along the vitelline membrane, which is stainable with acid fuchsin. The chorion exists between the inner follicular epithelium and the test-cells, but not between the encroached cell-bodies and the vitelline membrane, and it is of uniform thickness. The chorion may be judged, therefore, to be secreted by the inner follicular epithelium.

SUMMARY

1) The ovarian ovum of *Cynthia roretzi* DRASCHE, when nearly approaching its mature stage, is covered by five envelopes, viz. the basement membrane, the outer follicular epithelium, the inner follicular epithelium, the chorion and the layer of test-cells, reckoning them in sequence from the outside to the inside.

2) Two kinds of follicle cells are found at the commencement of the movement of the oögonium from the germinal epithelium to the stroma of the ovary. With the growth of the oögonium, one kind goes to form the outer follicular epithelium, and other to form the inner follicular epithelium.

3) The test-cells are, at first, intercalated in the inner follicular epithelium, and are subsequently translocated from this epithelium to the outer zone of the oögonium.

4) At the stage of the complete extrusion of the test-cells, the chorion appears first between the inner surface of the inner follicular epithelium and the outer surface of the vitelline membrane and of each test-cell, being secreted from the inner follicular epithelium.

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EXPLANATION OF PLATE XVI

Figs. 1 and 2. Growing oögonia and follicle cells, illustrating the commencement of their moyement from the germinal epithelium to the stroma of the ovary and the presence of two kinds of the follicle cells. ×750.

Fig. 3. Peripheral part of a later, grown oögonium illustrating the appearance of a test-cell. ×1,800.

Fig. 4. An oögonium approaching maturation, showing its envelopes. ×300.

ABBREVIATIONS

chr   chorion.

i.f   inner follicle cell or follicular epithelium.

f.st   follicle style.

g ep   germinal epithelium of the ovary.

o   oögonium.

o.f   outer follicle cell or follicular epithelium.

ov.d   oviduct.

st   stroma of the ovary.

t.c   test-cell.

y.g   yolk granules.

Fig. 1.

Fig. 2

Fig. 3.

Fig. 4.

E. HIRAI: Egg-follicle Formation.
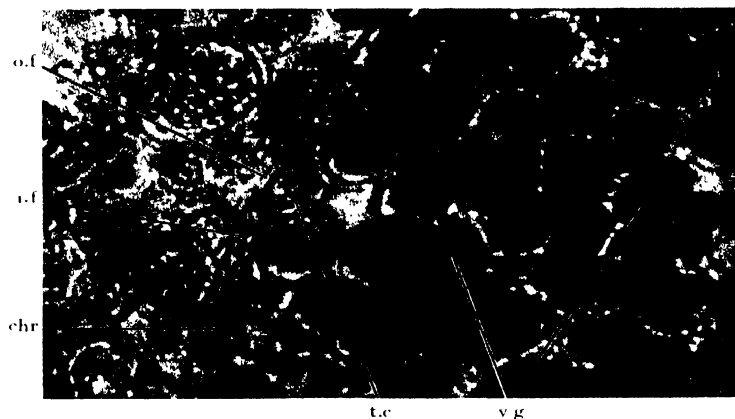
TWO NEW CALCAREA OBTAINED FROM SASEHO, JAPAN

By

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(With 4 text-figures)

(Received June 9, 1939)

The calcareous sponges dealt with in the present report were collected by Professor OHSHIMA of the Kyûshû Imperial University in December 1938, at Saseho, Nagasaki Prefecture, and forwarded to Professor HÔZAWA for identification. Through the courtesy of Professor HÔZAWA, I have had the opportunity of studying these materials.

In the collection there exist two species which seem to be new to science, and I propose to name them *Vosmaeropsis griseus*, n. sp. and *Leucandra ohshimai*, n. sp.

Before proceeding further, I should like to express my hearty thanks to Professor HÔZAWA for his kind guidance and to Professor OHSHIMA for his collection.

Vosmaeropsis griseus, n. sp.

This new species is based upon two specimens. Each of them represents a solitary person of a cylindrical form, broad at the base and narrowing towards the osculum. The dermal surface hispid from the projecting oxea. The gastral surface appears feebly hispid on account of the projecting apical rays of gastral quadriradiates, and is perforated by apertures of exhalant canals of variable sizes. The colour in alcohol is greyish white, and the texture is fairly firm.

The first specimen (Text-fig. 1) which I make the type of the species is in the form of a nearly straight cylindrical tube, more or less laterally compressed, with a height of about 40 mm. and a maximum diameter of 10 mm. The sponge wall is about 2 mm. thick in the middle parts of the body. The osculum at the upper end is provided with a feebly developed collar, and is about 4 mm. long by 3 mm. broad.

The other specimen is smaller than the former and is strongly bent. It is about 25 mm. in length and is 9 mm. broad in the thickest parts, the wall being about 2.5 mm. in thickness.

Structure. - The canal system is of the leuconoid type, though not very typical, representing some characteristics of the sylleibid type. The flagellate chambers found near the gastral surface are of oval shape, while those situated near the dermal are more elongate. Many of these chambers are thickly and irregularly packed in the chamber layer.

The skeleton of the dermal cortex consists of tangentially placed triradiates which are rather irregularly and thickly set, and of paired rays of subdermal pseudosagittal triradiates. In addition to these spicules, a number of large oxea and many linear spicules occur in the dermal skeleton standing almost at right angles to the dermal surface. Of the large oxea with their inner ends deeply implanted in the chamber layer, or even projecting into the gastral cavity, their outer ends project beyond the dermal surface to some extent.

Text-fig. 1. *Vosmaeropsis griseus*, n sp. ×1½.

The skeleton of the chamber layer consists of (1) the centripetally directed basal rays of the subdermal pseudosagittal triradiates, (2) tubar sagittal triradiates, (3) tubar quadriradiates which are relatively few in number, (4) the centrifugally directed basal rays of the subgastral triradiates, and (5) the inner portions of the large oxea, whose outer portions project through the dermal cortex.

The gastral skeleton is made up of slender triradiates, quadriradiates with their apical rays projecting into the gastral cavity, and of paired rays of subgastral triradiates. The former two kinds of spicules are arranged tangentially with their basal rays directed downwards.

The oscular margin is supported by large oxea, linear spicules, triradiates and quadriradiates. The first two kinds of spicules run longitudinally and parallel with the basal rays of the remaining spicules. Otherwise there is no any spiculation proper to the osculum.

Spicules (Text-fig. 2). — Dermal triradiates (a) slightly sagittal. Rays equally thick, lying in one plane. Basal ray straight, slightly longer than paired rays, 195 250 μ long and 12-18 μ thick at base. Paired rays equal,

either straight or very slightly curved backwards, 180–230 μ long and 12–18 μ thick at base.
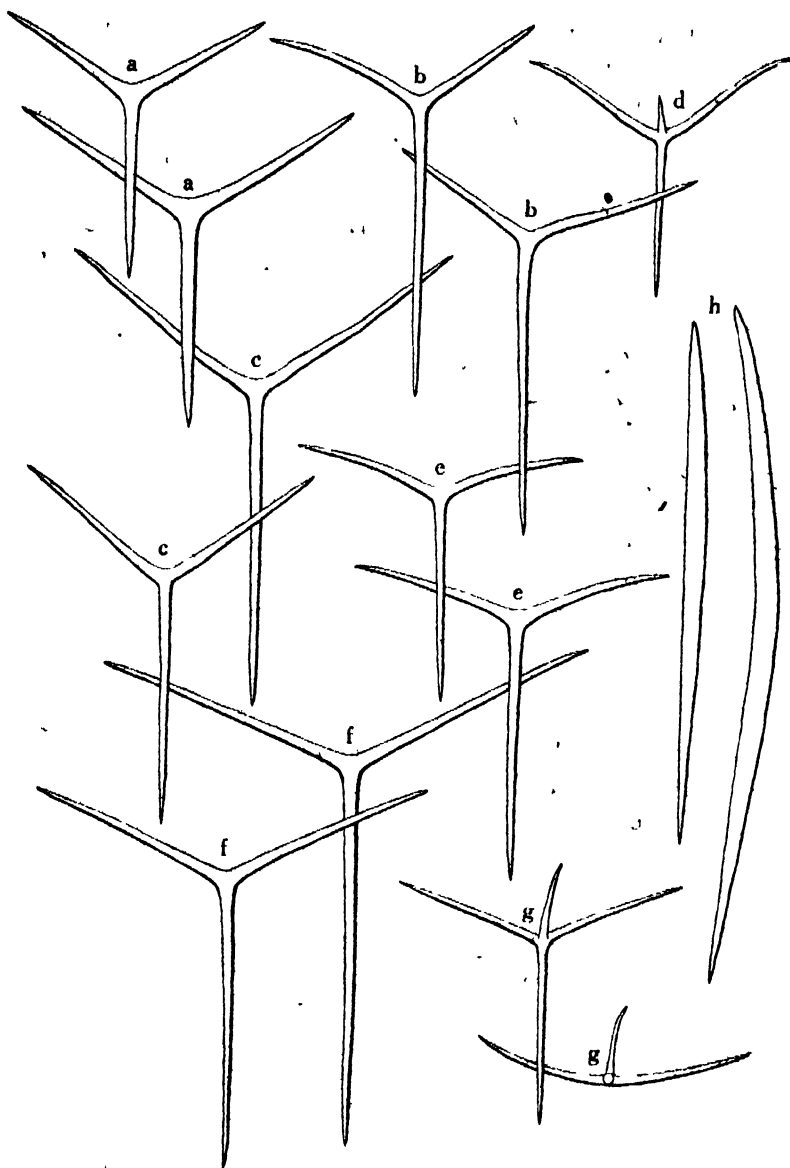
Text-fig. 2. *Vosmaeropsis griseus*, n. sp. *a*, Dermal triradiates. *b*, Subdermal triradiates. *c*, Tubar triradiates. *d*, Tubar quadriradiate. *e*, Subgastral triradiates. *f*, Gastral triradiates. *g*, Gastral quadriradiates. *h*, Large oxea. (*a–g* ×120; *h* ×60)

Subdermal triradiates (*b*) pseudosagittal. All the rays are of different length, but are nearly equally thick. Basal ray straight, sharply pointed, longer than paired rays, 200–255 μ long and 10–14 μ thick at base. The longer paired ray usually curved forwards, but sometimes irregularly curved, 150–190 μ long and 10–14 μ thick at base. The shorter-paired ray nearly straight, 125–160 μ long and 10–14 μ thick at base.

Tubar triradiates (*c*) strongly sagittal and variable in size. Basal ray straight, longer than paired rays, 150–320 μ long and 8–12 μ thick at base. Paired rays equal, curved either forwards or irregularly, 100–260 μ long and 8–12 μ thick at base.

Tubar quadriradiates (*d*) nearly similar to tubar triradiates except in the presence of apical ray. Apical ray straight, finely pointed, about 30 μ long and 10 μ thick at base.

Subgastral triradiates (*e*) sagittal with a wide oral angle. Basal ray straight, longer than paired rays, 250–290 μ long and about 12 μ thick at base. Paired rays almost of equal length, slightly curved forwards, 220–250 μ long and 12 μ thick at base.

Gastral triradiates (*f*) sagittal and slender. Basal ray straight, longer than paired rays, 220–300 μ long and 7–10 μ thick at base. Paired rays equal, nearly straight, 160–240 μ long and 7–10 μ thick at base.

Gastral quadriradiates (*g*) similar to triradiates of the same, differing only in the presence of apical ray. Apical ray sharply pointed, curved upwardly, shorter than the facial rays, 90–180 μ long and 7–10 μ thick at base.

Large oxea (*h*) spindle-shaped, slightly curved, pointed at both ends, variable in length, 650 μ–1.3 mm. long and 20–38 μ thick in the thickest portion. The oxea found in the oscular margin are exactly similar to those seen in the sponge body.

Linear spicules of the dermal surface very -fine, straight, sharply pointed at both ends. When they are perfect, they measure up to 600 μ in length and are 2 μ thick.

Remarks. — This species seems to be closely related to RIDLEY's *Vosmaeropsis sericatum*, but may be distinguished from it by the features of the oscular margin, by the canal system, and by the dimensions of the spicules.

Locality. — Saseho, Nagasaki Prefecture.

Leucandra ohshimai, n. sp.

This species is based on three specimens which were collected by

Prof. Ohshima in Sascho Bay on December 29th 1938. They are all of a closely similar appearance. Each of them represents a solitary person of a tubular form, the lower parts broad and laterally compressed and narrowing towards the upper osculum.

The first specimen (Text-fig. 3) which is herewith taken as the type is about 27 mm. in length and is 10 mm. broad at the broadest lower portion. The sponge wall is about 1 mm. thick in the middle of the body. The osculum at the upper end is nearly circular with a diameter of 1.5 mm. and is surrounded by a very feebly developed collar.

The dermal surface appears nearly smooth to the naked eye. The gastral surface is also nearly smooth but is perforated by many large exhalant pores. The gastral cavity extends the entire length of the body. The colour is yellowish grey in alcohol and the texture is rigid.

Structure. – The canal system is leuconoid. The flagellate chambers are closely and irregularly packed in the chamber layer. They are spherical or oval in shape with a diameter of 70–130 μ.

Text-fig. 3. *Leucandia ohshimai*, n. sp. $\times 1\frac{1}{2}$.

The dermal skeleton is composed of the following elements: 1) smaller sagittal triradiates which are tangentially arranged in a few layers without any orientation, 2) larger regular triradiates which are found among the smaller triradiates above mentioned, and 3) microxea which cover the entire external surface, being disposed at varying angles to the surface.

The tubar skeleton consists of triradiates in an irregular arrangement and of basal rays of subgastral triradiates. In addition to the spicules above mentioned I have met with a few tubar quadriradiates, which do not seem to be characteristic but only occasional. Along the larger exhalant canals there occur some quadriradiates with their apical rays projecting into the canal.

The gastral skeleton is fairly well distinguished from that of the chamber layer. It is made up of paired rays of subgastral triradiates and of tri- and quadriradiates. The latter two elements are arranged tangentially in a few layers with their basal rays pointing downwards.

The oscular margin is composed of gastral triradiates and of microxea which are arranged transversely running parallel with one another.

Spicules (Text-fig. 4). — The smaller dermal triradiates (*a*) sagittal. Rays nearly equally thick, lying in one plane. Basal ray straight, sharply pointed, longer than paired rays, 170–255 *µ* long and 10–18 *µ* thick at
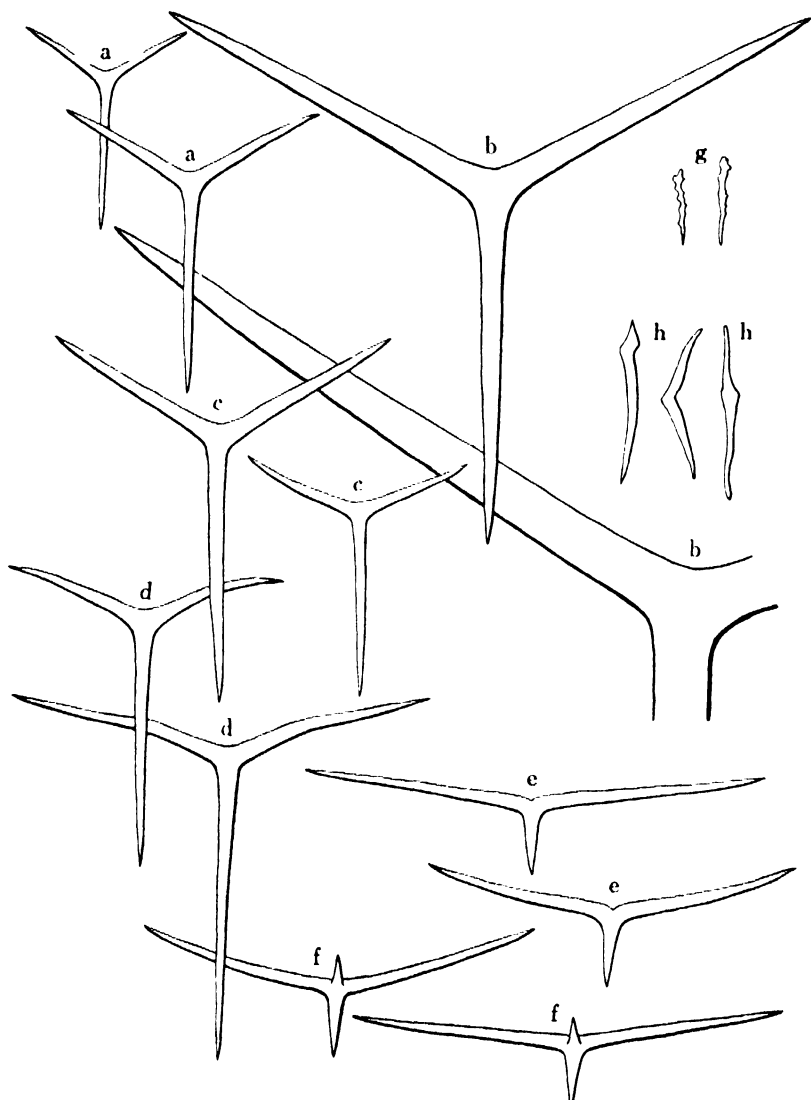
Text-fig. 4. *Leucandra ohshimai*, n. sp. *a*, Smaller dermal triradiates. *b*, Larger dermal triradiates. *c*, Tubar triradiates. *d*, Subgastral triradiates. *e*, Gastral triradiates. *f*, Gastral quadriradiater. *g*, Dermal microxea. *h*, Microxea of the oscular margin. (*a*–*f* ×120; *g*–*h* ×240)

base. Paired rays equal, straight or slightly curved backwards, 120–210 μ long and 10–18 μ thick at base.

The larger dermal triradiates (b) regular. Rays stout, more or less irregular in outline, 390–780 μ long and 38–70 μ thick at base.

Tubar triradiates (c) sagittal. Basal ray straight, longer than paired rays, 250–330 μ long and 14–20 μ thick at base. Paired rays equal, either straight or slightly curved forwards, sharply pointed, 160–230 μ long and 14–20 μ thick at base.

Subgastral triradiates (d) strongly sagittal. Rays are of equal thickness being 16–20 μ at base. Basal ray straight, much longer than paired rays and 270–340 μ long. Paired rays nearly equal, widely divergent, curved backwards and 170–240 μ long.

Quadriradiates of the larger exhalant canals similar to gastral quadriradiates which will be stated later on.

Gastral triradiates (e) strongly sagittal. All rays nearly equally thick, terminating in sharp points. Basal ray straight, much shorter than paired rays, 50–80 μ long and 14–18 μ thick at base. Paired rays widely divergent, slightly curved forwards, 220–270 μ long and 14–18 μ thick at base.

Gastral quadriradiates (f) similar to gastral triradiates, differing only in the presence of apical ray. Apical ray sharply pointed, nearly straight, shorter and thinner than facial rays, about 25 μ long and 10 μ thick at base.

Dermal microxea (g) nearly straight, provided with many spine-like protuberances on the surface. Proximally each tapers to a sharp point and distally terminates in a blunt end, measuring about 50 μ in length and 8 μ thick in the thickest parts.

Microxea of the oscular margin (h) more or less curved and are variable in shape. Some of these spicules are lance-headed, some others are provided with a nodiform ring in the middle, and some are bent irregularly. Average length of these spicules is about 100 μ.

Remarks. — In the spiculation this new species bears a marked resemblance to HôZAWA's *Leucandra dura*, but may be easily distinguished from it by the external appearance and by the absence of gastral microxea. The shape of dermal microxea and the arrangement of microxea in the oscular margin appear to be characteristics to this species. I take pleasure in naming this interesting species after Professor OHSHIMA, the collector of the specimens.

Locality. — Saseho, Nagasaki Prefecture.

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MITOSEN IM SPORANGIUM VON *LAMINARIA JAPONICA* ARESCH.[1]

Von

KôGORô ABE

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(Mit Tafeln XVII-XVIII)

(Eingegangen am 6. Juli 1939)

Unter den Phaeophyceen ist die Gattung *Laminaria* die wichtigste Nutzpflanze. Über die verschiedenen japanischen Arten dieser Gattung hat KANDA ('36, '38) ganz genaue Kulturversuche ausgeführt. Auf jeden Fall stimmen seine Ergebnisse mit denen von SAUVAGEAU ('16), KYLIN ('16) u. a. überein. Die Mitosen im unilokulären Sporangium dieser Gattung sind aber bis jetzt noch von niemandem untersucht worden. Im letzten Herbst sammelte ich also das Material während meines zweiwöchigen Aufenthalts im Muroran Institut für Phykologie der Kaiserlichen Hokkaidô Universität zu Sapporo.

Als Material gebrauchte ich *Laminaria japonica* ARESCH.; die Pflanze wuchert in dieser Gegend sehr üppig. Die verschiedenen karyokinetischen Stadien lassen sich selbst beim lebenden Material mit Essigkarmin fast genau erkennen. Darum ist es nicht schwierig, das Material in den geeigneten Stadien zu fixieren.

Das Material wurde mit der Lösung, welche ich bei der Untersuchung von *Sargassum* (ABE '36), *Desmarestia* (ABE '38) und *Heterochordaria* (ABE '36) verwandt hatte, meistens 20-24 Stunden lang fixiert. Um mit diesem Fixierungsmittel gute Ergebnisse zu erzielen, ist es wesentlich, das Sorus so klein wie möglich zu zerschneiden. Die 4-5 μ dick geschnittenen Paraffinschnitte wurden mit HEIDENHAINS Eisenalaunhämatoxylin gefärbt.

Fig. 1 zeigt den im vollständigen Ruhestadium sich befindlichen Kern des unilokulären Sporangiums. In diesem Stadium beträgt der Durchmesser des Kerns etwa 4-5 μ. Ein Synapsisstadium kann man in Fig. 3 ersehen. Häufig bemerkte ich zwei synaptische Knäuel an beiden Seiten des Kerns, wie Fig. 4 zeigt. Das Spirem- und Diakinesestadium folgt darauf (Figg. 5-7). Die bivalenten Chromosomen zeigen verschiedene

Formen, wie aus Fig. 6 hervorgeht. Bei solchen Stadien konnte ich feststellen, dass die Zahl der Gemini etwa 22 ist. Mit der Auflösung der Kernmembran ordnen sich die Chromosomen auf der Äquatorialebene an (Figg. 8–10). Figg. 9–10 zeigen die Metaphase in der Seitenansicht. In Fig. 9 ist ein zentrosomähnliches Körperchen in nur einem Pole der Spindel sichtbar, während in Fig. 12 davon nichts zu ersehen ist. Leider gelang es mir nicht, eine gute, die haploide Chromosomenzahl dieser Alge klar zeigende Polansicht der Kernplatte zu finden. Die Ana- und Telophase geht normal vor sich (Figg. 11–12). Dann beginnt die homöo-type Teilung (Figg. 13–14). In Fig. 13 sieht man ein zentrosomähn-liches Körperchen in jedem Pole in nur einer Spindel. Nach dieser homöotypen Teilung entstehen vier Kerne (Fig. 15), die dann noch weitere Teilungen ausführen (Figg. 16–18). Inzwischen vergrössert sich das Sporangium allmählich. Nach der fünften Teilung sieht man im Sporangium 32 freie Kerne (Fig. 19), welche dann durch dünne proto-plasmatische Scheidewände in Sporen getrennt werden. An der Spitze des reifen Sporangiums ist die Zellwand wegen der Verschleimung stark verdickt (Fig. 20).

Aus obigen Resultaten ist es sicher, dass die Individuen mit uniloku-lären Sporangien diploid und die zwei vorersten Kernteilungen im Spo-rangium die Reduktionsteilungen sind, wie bei anderen Pflanzen von Laminariales, z. B. *Chorda filum* (KYLIN' 18), *Egregia Menziesii* (MEYER '28) und *Pterygophora Californica* (MCKAY '33). *Laminaria* zeigt also einen regelmässigen Generationswechsel zwischen einer zwerghaften ge-schlechtlichen haploiden und einer stattlichen ungeschlechtlichen diploiden Generation.

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TAFELERKLÄRUNG

Alle Figuren wurden mit Hilfe eines ABBÉschen Zeichenapparatus gezeichnet, unter Benutzung des ZEISschen Objektiv, Ölimmersion 1/12, des LEITZschen Objektiv 7 und des ZEISschen Okular ×17. Vergrösserung. Figg. 1-18 ×2400, Figg. 19-20 ×2000.

TAFEL XVII–XVIII

Fig. 1. Ruhestadium. Fig. 2. Früheste Prophasestadium. Fig. 3. Synapsisstadium. Fig. 4. Dasselbe mit zwei sypnatischen Knäueln. Fig. 5. Spiremstadium. Figg. 6-7. Diakinese. Fig. 8. Frühere Metaphase. Figg. 9-10. Vollständige Metaphase in Seitenansicht. Fig. 11. Anaphase. Fig. 12. Telophase. Fig. 13. Homöotype Metaphase. Fig. 14. Homöotype Anaphase. Fig. 15. Homöotype Telophase. Fig. 16. Prophase in der dritten Teilung. Figg. 17-19. 8-32 kerniges Stadium. Fig. 20. Voll reifes Sporangium.
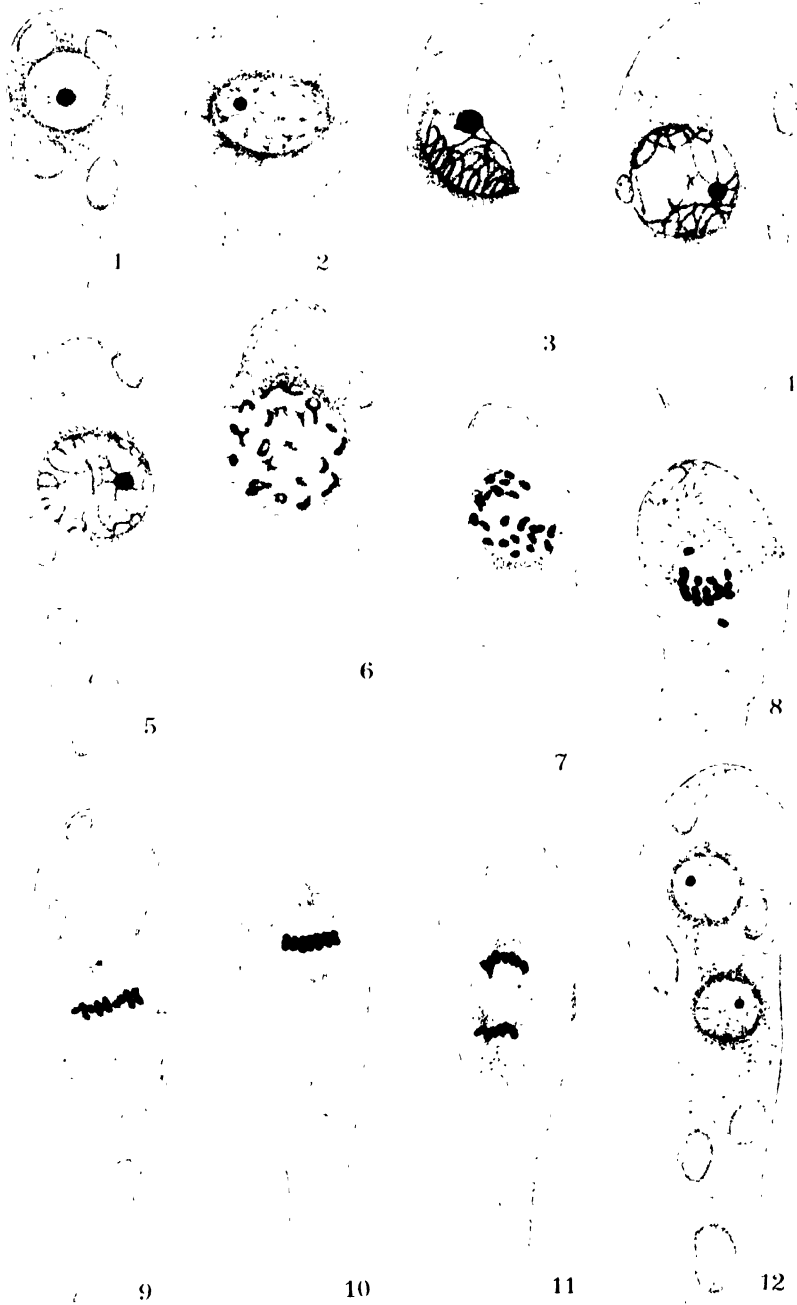
K. ABE: Mitosen im Sporangium von Laminaria.
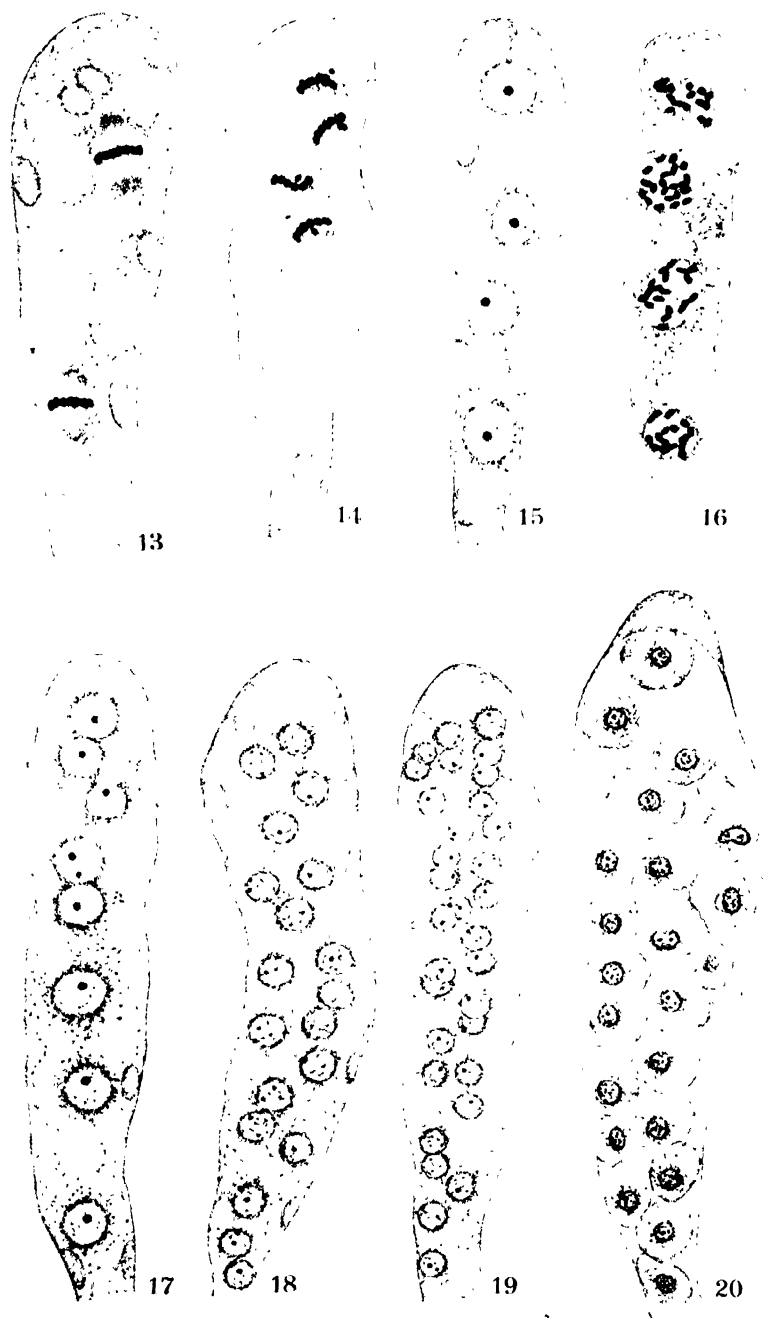
K. Abe : Mitosen im Sporangium von Laminaria.

EFFECT OF ADRENALINE UPON THE EARTHWORM

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(With 11 text-figures)

(Received July 26, 1939)

The effects of adrenaline in invertebrates have been studied and re-
ported by numerous investigators. Annelids have also been studied in
this respect by various workers: MAGNUS (1903), GASKELL (1914),
HOGBEN and HOBSON (1923), MENNICKE (1925), and others. The results
of their experiments are diverse, and the present study with the earthworm
was undertaken in order to confirm their results.

I am greatly indebted to Prof. S. NOMURA, under whose direction
this work was carried out, for useful suggestions and encouragement.

MATERIAL AND METHOD

The material used in the present work was the earthworm, *Allo-
lobophora foetida* (SAV.) (Synonym: *Eisenia foetida*). The identification of
the species was kindly carried out by Dr. OHFUCHI to whom I wish here
to express my sincere thanks.

In the first series of experiments, preparations of muscle-nerve com-
plex were made from the posterior part of the body, about 1.5 to 2.0 cm.
long and comprising about 8 to 13 segments with the ventral nerve cord
intact. In the second series of experiments the earthworm was narcotized
with chloretone and opened along the dorsal median line and the ventral
nerve cord was removed, leaving the alimentary canal *in situ*. Pieces of
the body similar to those in the first series were prepared. In the third
series, the ventral side of the body wall with the ventral nerve cord was
removed and the rest of the body was cut into the same lengths as in
the previous series, a narcotic not being used at this time as the pre-
paration was simple in this case.

One of the ends of the piece was fixed by means of a piece of thread
to the bend of the glass rod supported in the vessel and the other end
of the preparation was similarly connected to the tracing lever. As the
medium for the immersion of the preparation, RINGER's solution of ordinary

composition for frogs was employed after being diluted down to 65%, to adjust it to the osmotic pressure in the earthworm. M/100 NaHCO₃ solution was used for dilution, instead of distilled water, to regulate the hydrogen ion concentration. The resulting solution had pH of 6.9.

20 c.c. of this solution were used for each experiment. After obtaining the normal curve of the rhythmic contraction of the muscle preparation, the immersion fluid of the above composition was replaced by the experimental solution of adrenaline chloride (Sankyo Co.) of the desired concentration in the diluted RINGER solution above mentioned, delivered from a pipette. An exchange of the immersion fluids was carefully performed avoiding disturbance of the preparation as far as possible.

The animals were collected from the habitat near the laboratory and used for experiments during the day of collecting while still healthy and vigorous.

RESULT OF EXPERIMENT

I. Effect of adrenaline on the preparation with the ventral nerve cord intact.

a) The tonus of the muscle was remarkably increased for a short period (18~24 seconds) after the normal immersion medium was replaced with the adrenaline solution (1.10^{-4}) in the diluted RINGER (65%); and the frequency of the rhythmic contraction increased by 170%~300%, but the amplitude of contraction decreased. Then the tonus decreased and the frequency was lowered below the normal down to 38~67% (Fig. 1). In the solutions of adrenaline 5.10^{-5}~2.10^{-5}, the tonus and the frequency of contraction at first increased, but the amplitude decreased, then the tonus and the frequency were both decreased as was the case with the solution of a concentration of 1.10^{-4} (Fig. 2). In the concen-
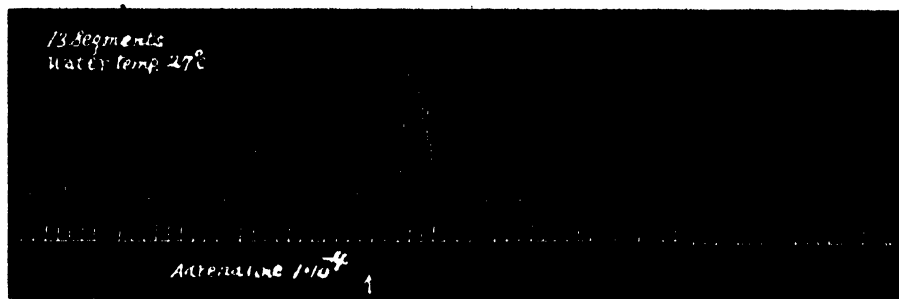
Fig. 1.
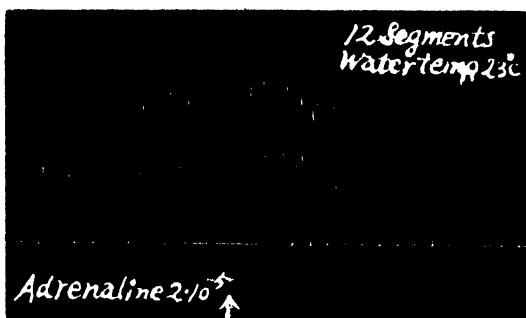
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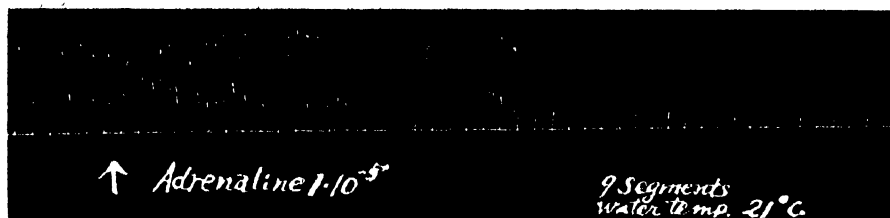
Fig. 3.
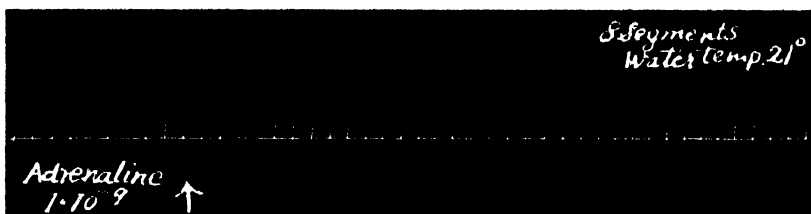
Fig. 4.
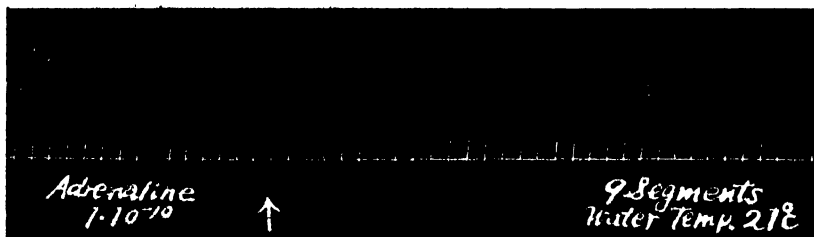
Fig. 5.

Figs. 1-5. The effects of adrenaline on the muscle piece with the ventral nerve cord intact. Arrows indicate addition of adrenaline; time in 6 seconds.

tration of 1.10^{-5}, the tonus was perceivably increased at first, then returned to normal and later was lower than normal (Fig. 3). The frequency was also decreased.

b) In the concentrations of adrenaline $1.10^{-6} \sim 1.10^{-10}$, the rise of tonus, such as was observed at the higher concentration of 1.10^{-4} to 1.10^{-5}, could not be perceived, and more or less.of a decrease in tonus and frequency was observed from the beginning (Figs. 4 and 5). At concentrations of 1.10^{-7}, the inhibitory effect of adrenaline appeared immediately, while at a concentration of 1.10^{-9} the effect appeared slowly and slightly; at a concentration of 1.10^{-10}, the distinct effect persisted only for a brief period and the muscle soon tended to recovery.
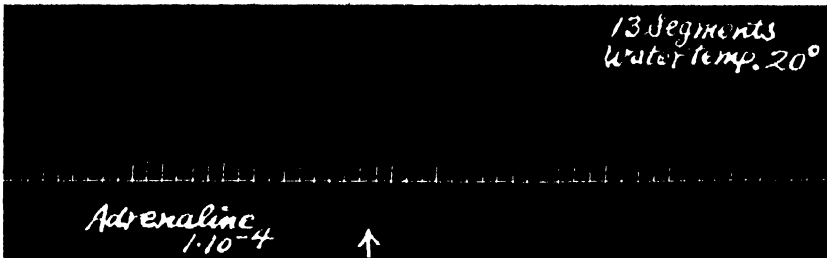
Fig. 6.

Fig. 7.
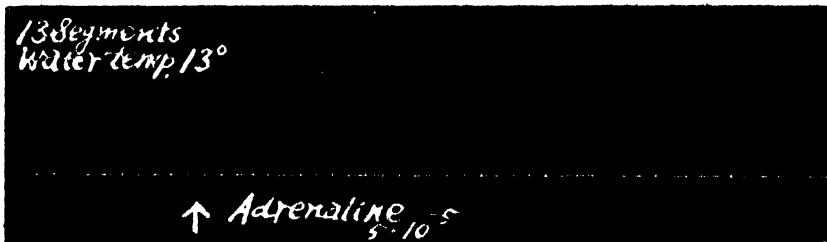
Fig. 8.
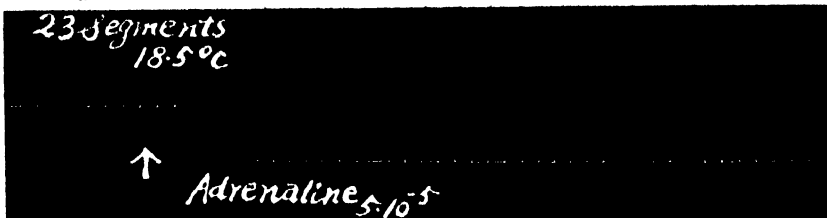
Fig. 9.

Figs. 6-9. The effects of adrenaline on the muscle piece with ventral nerve cord removed.

II. Effect of adrenaline upon the body wall muscle with the ventral nerve cord removed.

The frequency of the contraction of preparations with the ventral nerve cord extirpated was very small, and the effect of adrenaline even at a concentration of as high as 1.10^{-4} was almost imperceptible (Figs. 6 and 7) in some cases and the tonus was raised in others (Fig. 8). Still another case showed a decrease in the tonus (Fig. 9) and thus the results were not in accord with one another.

III. Effect of adrenaline on the muscle preparations from the dorsal side.

The musculature of the ventral side together with the ventral nerve cord were removed, and the contractions observed in this series of experiments were thus due to the musculature of the dorsal body wall. The rhythm of contraction in the control preparation was irregular and indistinct. The effect of adrenaline upon such preparations as these just described was, however, distinct. Adrenaline at concentrations of 1.10^{-4} to 1.10^{-5} distinctly accelerated contraction, but the relaxation was quite slow (Figs. 10 and 11).
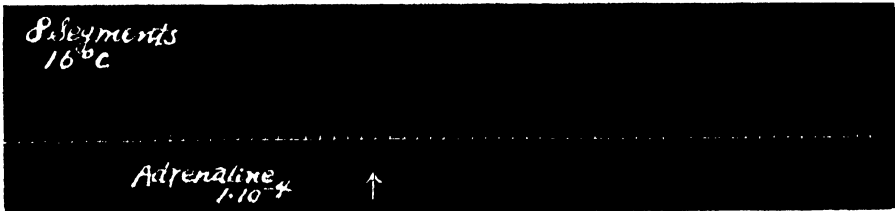
Fig. 10.
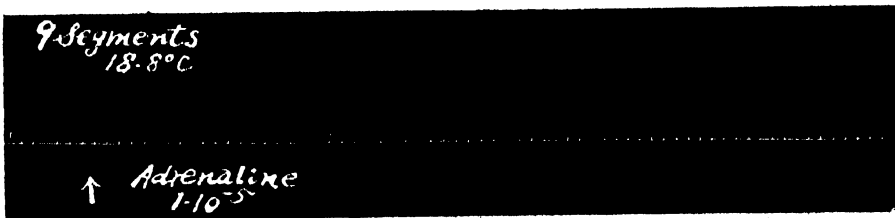
Fig. 11.

Figs. 10-11. The effects of adrenaline on the muscle piece from the dorsal side.

COMPARISON AND DISCUSSION

Recent literature on the effects of adrenaline on invertebrate tissues was briefly reviewed by NOMURA, revealing discrepancies in the results

of experiments by previous authors. Some of the results obtained by recent authors may here be added and compared. BEAUVALLET (1938) observed on the intestine of *Helix* that adrenaline at lower concentrations did not show any remarkable action, but at higher concentrations it distinctly raised the tonus, and increased the frequency, while the amplitude was decreased. The tonus returned to the initial level after a few minutes. The results at higher concentrations here cited agree with the results of the first series of our experiment with higher concentrations of adrenaline. WYMAN and LUTZ (1930) worked with the isolated cloaca of Holothuria, and found that adrenaline gradually decreased the tonus and increased the amplitude and the rate of contraction. According to WELLS (1937) the most characteristic effect of adrenaline upon the oesophagus (extrovert) of *Arenicola marina* L. can be observed at the concentrations of adrenaline between 1.10^{-8} and 1.10^{5}. At a concentration of 1.10^{-5}, the tonus of the tissue remarkably increased, and the amplitude was decreased in some preparations.

HYKÈS (1929) worked with the heart of *Pterotrachea mutica* and reports that the adrenaline effect is inhibitory at higher concentrations and excitatory at lower concentrations. MAGNUS (1930) reports that adrenaline exerts no effect upon the muscle of *Sipunculus*, and GASKELL (1914) observed no effect of adrenaline in *Hirudo* and *Lumbricus*, except the excitatory action of adrenaline upon the pulsation of blood vessels in *Hirudo*. STROSS also could find adrenaline effects neither in *Hirudo* nor in the earthworm.

HOGBEN and HOBSON (1923) on the contrary observed excitatory effects of adrenaline upon the isolated pharynx of *Aphrodite aculeata*. MENNICKE (1925) worked with the earthworm, and found that adrenaline showed no effect upon the normal muscle preparation (with the ventral nerve cord) while it was excitatory to preparations with the ventral cord removed. The results of his experiments and our own do not agree, and the discrepancies do not seem to be easily explicable.

It is, therefore, premature to draw, from the results of these experiments, any conclusion as regards the presence of a sympathetic nervous system in the earthworm, and the problem has been left open for further studies.

SUMMARY AND CONCLUSION

1. The effect of adrenaline upon the muscle of the body wall of *Eisenia foetida* has been studied

2. The concentrations of adrenaline that were tested ranged from 1.10^{-4} to 1.10^{-10} in diluted RINGER solution, isotonic with the earthworm.

3. The effect of adrenaline at higher concentrations upon the muscle preparation with the ventral nerve cord is excitatory at first, then becomes inhibitory afterwards.

4. At lower concentrations, the excitatory effect was not observed and the inhibitory effect appeared from the beginning.

5. The response of the muscle preparation deprived of the ventral nerve cord was not definite even at higher concentrations of adrenaline.

6. The muscle preparation from the dorsal side of the body wall alone (without the ventral nerve cord) responded to a higher concentration of adrenaline (1.10^{-1}) with prompt and distinct contraction followed by gradual relaxation.

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STUDIES ON THE ECHIUROIDEA, SIPUNCULOIDEA AND PRIAPULOIDEA OF JAPAN

By

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(With Plates XIX–XXIII, 60 text-figures, and 16 tables)

(Received September 12, 1939)

CONTENTS

I. INTRODUCTION

Before the publication of the systematic monograph on Gephyrea written by the late Professor Dr. IKEDA in 1904, only four species of the group had been recorded from Japan, viz. *Urechis unicinctus* (VON DRASCHE), *Physcosoma japonicum* (GRUBE), *Dendrostoma blandum* SELENKA & DE MAN and *Phascolion lucifugax* SELENKA & DE MAN. In his admirable monograph mentioned above, IKEDA described 37 species of Gephyrea from Japanese waters. Of these 37 species, 24 were newly established at that time by him and the remaining 13 species were identified with forms hitherto described.

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Since 1904, the year of the publication of IKEDA's monograph, many new species have been added to Japanese Gephyrean fauna by the authors mentioned in the following list:

1908. I. IKEDA, Notes on a New Deep-sea Echiuroid, *Protobonellia mitsukurii*, n. sp.

1908. I. IKEDA, On a New Echiuroid, *Hamingia ijimai* from Sagami Bay.

1909. A. OSTROUMOV, Sur les géphyreens du nord de la mer du Japon.

1910. I. IKEDA, Notes on a Deep-sea Echiuroid, *Acanthohamingia shiplei.*

1924. I. IKEDA, Further Notes on the Gephyrea of Japan with Descriptions of Some New Species from the Marshall, Caroline and Palau Islands.

1930. H. SATÔ, Report of the Biological Survey of Mutsu Bay. 15. Sipunculoidea.

1931. H. SATÔ, Report of the Biological Survey of Mutsu Bay, 20. Echiuroidea.

1934. H. SATÔ, Report on the Sipunculoidea, Echiuroidea and Priapuloidea Collected by the Sôyô Maru Expedition of 1922–1930.

1934. S. OKUDA, Occurrence of *Priapulus caudatus* in Northern Japan.

1934. K. ONODA, On *Pseudobonellia*, a New Genus of the Bonellian Echiuroids.

1935. K. ONODA, '*Parabonellia*' (Nom. Nov.) *misakiensis* Correction of My Paper on '*Pseudobonellia*'.

1935. H. SATÔ, *Parabonellia misakiensis* (IKEDA) found in the Vicinity of the Simoda Marine Biological Station.

1935. H. SATÔ, Sipunculoidea and Echiuroidea of the West Caroline Islands.

1937. H. SATÔ, Echiuroidea, Sipunculoidea and Priapuloidea obtained in Northeast Honsyû, Japan.

1937. H. SATÔ, Note on a New Sipunculoid, *Physcosoma kurilense*, n. sp. found in Shumshir Island.

Thus at present the number of species of Gephyrea found in Japan has become more than double that shown in IKEDA's monograph published in 1904.

In 1936 and 1937, by the aid of the Foundation for the Promotion of Industrial and Scientific Research in Japan, the writer had opportunities to collect and examine the Gephyrea of Japan, obtaining the material chiefly from Formosa, the the Riukiu Islands and Korea.

The present paper deals with the results of the examination of the collections made in the localities mentioned above, and also deals with all of the species which were formerly described from Japanese waters.

From Formosa, to the writers knowledge, on the Gephyrean fauna no report has been made except for a short note by the late Mr. S. TAKAHASHI in 1934.* He reported in his paper two species, one belonging to Echiuroidea and the other to Sipunculoidea. In his report, however, neither the scientific names nor detailed accounts concerning the specific character of the fauna was given. But judging from the photograph inserted in his paper, the writer was able to prove that the one may belong to Echiuroidea and should be identified with *Ochetostoma erythrogrammon* (LEUCKART & RÜPPELL), while the other may belong to Sipunculoidea, but it is impossible to settle its specific name.

The species which the writer collected in Formosa, are twenty three in all : twenty two of which belong to Sipunculoidea and the remaining one to Echiuroidea.

The following is the list of the species obtained by the writer in Formosa during the collecting trips above mentioned.

ECHIUROIDEA

1. *Ochetostoma erythrogrammon* (LEUCKART & RÜPPELL)

SIPUNCULOIDEA

2. *Sipunculus nudus* LINNAEUS
3. *Sipunculus indicus* PETERS
4. *Siphonosoma cumanense* (KEFERSTEIN)
5. *Siphonosoma edule* SLUITER
6. *Siphonosoma formosa*, n. sp.
7. *Siphonosoma pescadolense*, n. sp.
8. *Physcosoma scolops* (SELENKA & DE MAN)
9. *Physcosoma albolineatum* (BAIRD)
10. *Physcosoma varians* (KEFERSTEIN)
11. *Physcosoma japonicum* (GRUBE)

* S. TAKAHASHI, 1934. Note on the Sea-shore Animals found Near Kirun. Kagaku no Taiwan, Vol. II, No. 5-6, p. 28.

12. *Physcosoma nigrescens* (KEFERSTEIN)
13. *Physcosoma pacificum* (KEFERSTEIN)
14. *Physcosoma onomichianum* (IKEDA)
15. *Physcosoma formosense*, n. sp.
16. *Phascolosoma pyriformis* LANCHESTER
17. *Phascolosoma vulgare* (DE BLAINVILLE)
18. *Aspidosiphon steenstrupii* (DIESING)
19. *Aspidosiphon elegans* (CHAMISSO & EYSENHARDT)
20. *Aspidosiphon grandis*, n. sp.
21. *Aspidosiphon makoensis*, n. sp.
22. *Aspidosiphon formosanus*, n. sp.
23. *Cloeosiphon aspergillum* (QUATREFAGES)

Of the twenty three species, seventeen are identical with species previously known, while the remaining six may be regarded as new to science. As is shown in the table mentioned above, it is an interesting fact from the view-point of distribution, that there is found *Ochetostoma erythrogrammon* a unique species, representing the Echiuroid-fauna of Formosa. This is one of the cosmopolitan species occurring in the tropical region of the Pacific Ocean. Along the coast of Formosa, this species is very widely distributed.

From the present collection, as is shown in the map in Text-fig. 1, we see that the fauna of these groups of animals is richest in the regions occupying both the southern and the northern extremities of Formosa, while no specimen was found in the region located along the west coast of Formosa extending from Tansui to Tôkô.

From the Riukiu Islands, only a single report on Gephyrea has hitherto been made, that is by IKEDA in 1904. He mentioned in that report the following fourteen species, viz. *Thalassema inansense* IKEDA, *Ochetostoma erythrogrammon* (LEUCKART & RÜPPELL), *Bonellia fuliginosa* ROLANDO, *Bonellia miyajimai* IKEDA, *Physcosoma scolops* (SELENKA & DE MAN), *Physcosoma antillarum* (GRUBE & OERSTED), *Physcosoma pacificum* (KEFERSTEIN), *Physcosoma nahaense* (IKEDA), *Siphonosoma amamiense* (IKEDA), *Siphonosoma cumanense* (KEFERSTEIN), *Aspidosiphon truncatus* (KEFERSTEIN), *Aspidosiphon steenstrupii* (DIESING), *Cloeosiphon aspergillum* (QUATREFAGES).

During a visit to the Riukiu Islands in April of 1936, the writer had a chance to collect a number of specimens of Gephyrea. The following is the list of species based chiefly on thé material mentioned above. An

interesting Echiuroid worm (*Listriolobus riukiuensis*, n. sp.) is appended also added to it.   The specimen of this new Echiuroid was kindly presented to the writer by Professor Dr. H. OHSHIMA of the Kyûsyû Imperial University, it having been obtained by himself in that island on Feb. 26, 1937.
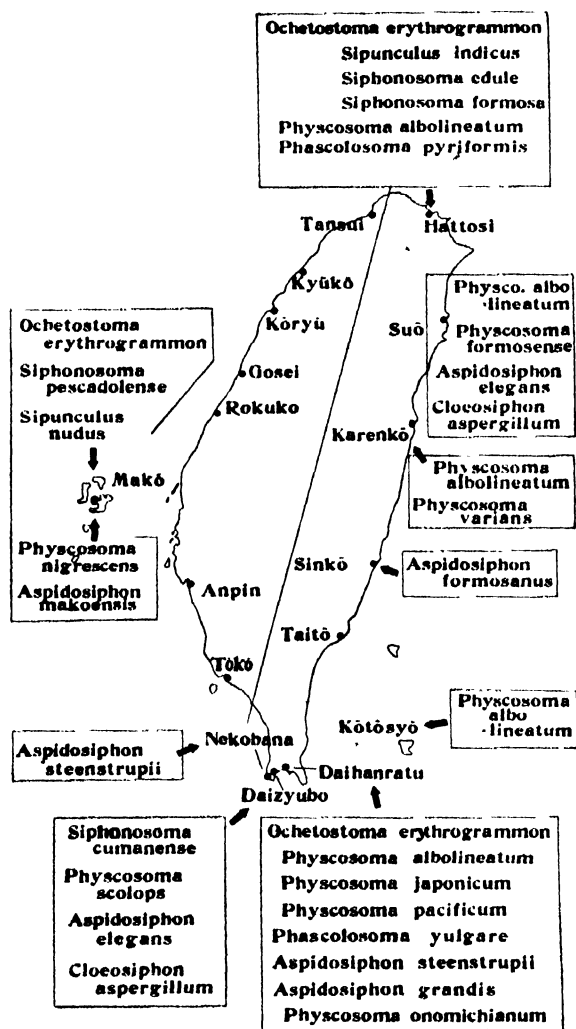
Text-fig. 1, A map of Formosa, showing the distribution of Echiuroidea and Sipunculoidea obtained in Formosa in the present collection.

ECHIUROIDEA

1. *Listriolobus riukiuensis*, n. sp.
2. *Ochetostoma erythrogrammon* (LEUCKART & RÜPPELL)

SIPUNCULOIDEA

3. *Siphonosoma cumanense* (KEFERSTEIN)
4. *Siphonosoma edule* (SLUITER)
5. *Siphonosoma amamiense* (IKEDA)
6. *Physcosoma albolineatum* (BAIRD)
7. *Phascolosoma pyriformis* LANCHESTER
8. *Aspidosiphon steenstrupii* DIESING

In Korea, the collection was carried out during August and September of 1937, and the following fifteen species were obtained from various localities as is shown in Text-fig. 2. Of the fifteen species, only one seems to be new to science and the remaining fourteen are identical with those previously described.

The following is the list of the species obtained in Korea.

ECHIUROIDEA

1. *Urechis unicinctus* (VON DRASCHE)
2. *Thalassema mucosum* IKEDA
3. *Thalassema sabinum* LANCHESTER
4. *Ochetostoma erythrogrammon* (LEUCKART & RÜPPELL)

SIPUNCULOIDEA

5. *Sipunculus nudus* (LINNAEUS)
6. *Siphonosoma cumanense* (KEFERSTEIN)
7. *Siphonosoma koreae*, n. sp.
8. *Phascolosoma vulgare* (DE BLAINVILLE)
9. *Phascolosoma catharinae* F. MÜLLER
10. *Physcosoma scolops* (SELENKA & DE MAN)
11. *Physcosoma granulatum* (LEUCKART)
12. *Physcosoma japonicum* (GRUBE)
13. *Physcosoma albolineatum* (BAIRD)
14. *Physcosoma onomichianum* (IKEDA)
15. *Aspidosiphon steenstrupii* DIESING

In the collection made in Korea, the majority of the material was taken by the writer, while several specimens were secured by the following four gentlemen: Mr. SHIRÔ OKUDA of the Hokkaidô Imperial Univer-

sity, Mr. TSUNEICHI KAMITA of the Keizyô Normal School, Mr. TSUKIJI
SATÔ of the same and Mr. HARUNOBU KURIHARA of the Keizô Girls'
Normal School.

From the present collection made in Korea, as is shown in the map
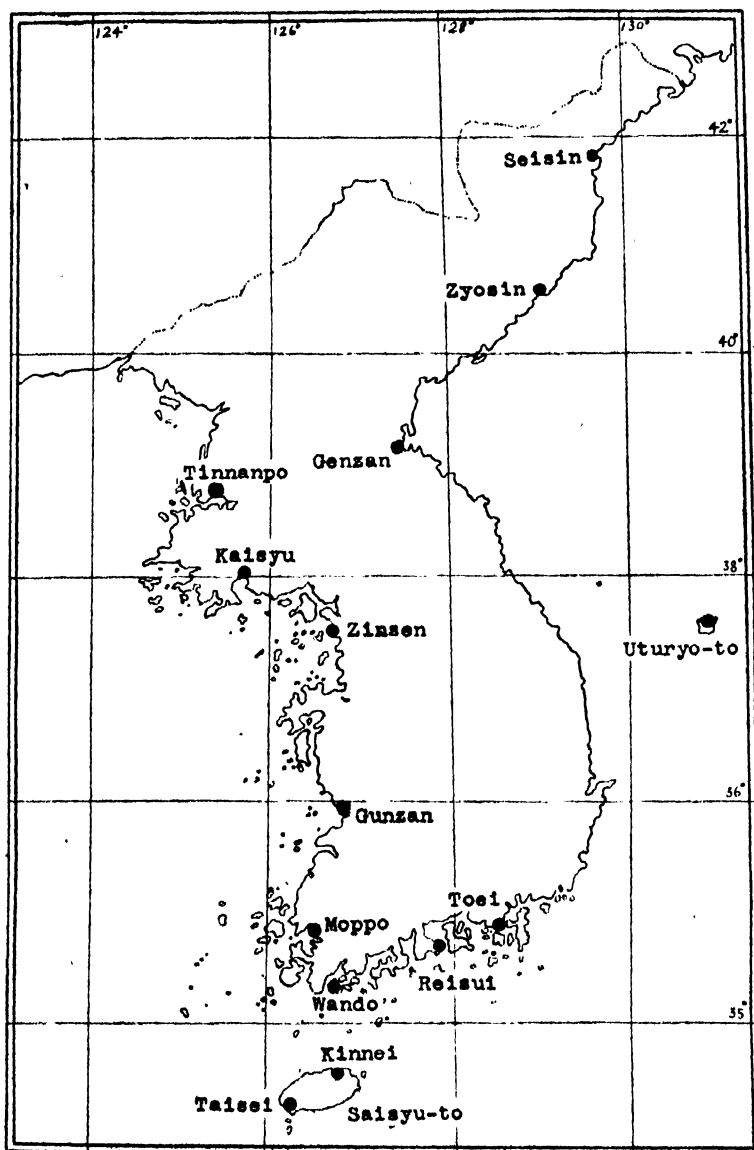
Text-fig. 2.   A map of Korea, showing the stations where the collection was made.

in Text-fig. 2, we learn that the fauna of this group is richest in the
region of Southern Korea, but is rather poor in the region along the
coast of the Japan Sea.

The taxonomic studies on Gephyrea above mentioned have been made
dealing chiefly with the materials obtained from the seas surrounding Japan
proper. In the present paper the writer has treated the specimens secured
not only from the seas of Japan proper, but also from those of Korea,
Formosa and Kurile Islands. Thus, at present, the number of Gephyrean
species known to inhabit the adjacent seas of Japan is 90 in all. Of the
said 90 forms, 19 belong to 11 genera of Echiuroidea, 69 to 9 genera
of Sipunculoidea, and the remaining 2. to a single genus of Priapuloidea.

The following is the list of species recorded in the present paper.

ECHIUROIDEA

1. *Urechis unicinctus* (VON DRASCHE)
2. *Echiurus echiurus* (PALLAS)
3. *Arhynchite arhynchite* (IKEDA)
4. *Thalassema sabinum* LANCHESTER
5. *Thalassema owstoni* IKEDA
6. *Thalassema fuscum* IKEDA
7. *Thalassema inansense* IKEDA
8. *Thalassema mucosum* IKEDA
9. *Thalassema elegans* IKEDA
10. *Thalassema gogoshimense* IKEDA
11. *Ikeda taenioides* (IKEDA)
12. *Ochetostoma erythrogrammon* (LEUCKART & RÜPPELL)
13. *Listriolobus riukiuensis*, n. sp.
14. *Bonellia fuliginosa* ROLANDO
15. *Bonellia miyajimai* IKEDA
16. *Protobonellia mitsukurii* IKEDA
17. *Parabonellia misakiensis* (IKEDA)
18. *Acanthohamingia shiplei* IKEDA
19. *Acanthohamingia ijimai* (IKEDA)

SIPUNCULOIDEA

20. *Sipunculus nudus* LINNAEUS
21. *Sipunculus indicus* PETERS
22. *Sipunculus robustus* KEFERSTEIN
23. *Siphonosoma cumanense* (KEFERSTEIN)

24. *Siphonosoma mourense* SATÔ
25. *Siphonosoma amamiense* (IKEDA)
26. *Siphonosoma edule* SLUITER
27. *Siphonosoma hataii* SATÔ
28. *Siphonosoma takatsukii* SATÔ
29. *Siphonosoma formosa*, n. sp.
30. *Siphonosoma pescadolense*, n. sp.
31. *Siphonosoma koreae*, n. sp.
32. *Physcosoma scolops* (SELENKA & DE MAN)
33. *Physcosoma japonicum* (GRUBE)
34. *Physcosoma granulatum* (LEUCKART)
35. *Physcosoma yezoense* IKEDA
36. *Physcosoma glaucum* SATÔ
37. *Physcosoma kurilense* SATÔ
38. *Physcosoma nigrescens* (KEFERSTEIN)
39. *Physcosoma pacificum* (KEFERSTEIN)
40. *Physcosoma varians* (KEFERSTEIN)
41. *Physcosoma antillarum* (GRUBE & OERSTED)
42. *Physcosoma pelma* (SELENKA & DE MAN)
43. *Physcosoma nahaense* (IKEDA)
44. *Physcosoma albolineatum* (BAIRD)
45. *Physcosoma onomichianum* (IKEDA)
46. *Physcosoma formosense*, n. sp.
47. *Phascolosoma vulgare* (DE BLAINVILLE)
48. *Phascolosoma pyriformis* LANCHESTER
49. *Phascolosoma catharinae* F MÜLLER
50. *Phascolosoma owstoni* IKEDA
51. *Phascolosoma okinoseanum* IKEDA
52. *Phascolosoma appendiculatum* SATÔ
53. *Phascolosoma glossipapillosum* SATÔ
54. *Phascolosoma japonicum* IKEDA
55. *Phascolosoma signum* SATÔ
56. *Phascolosoma margaritaceum* (SARS)
57. *Phascolosoma soyo* SATÔ
58. *Phascolosoma noto* SATÔ
59. *Phascolosoma nigrum* IKEDA
60. *Phascolosoma hyugense* SATÔ
61. *Phascolosoma hozawai* SATÔ
62. *Phascolosoma zenibakense* IKEDA

63. *Phascolosoma onagawa* SATÔ
64. *Phascolosoma misakianum* IKEDA
65. *Dendrostoma ellipticum* SATÔ
66. *Dendrostoma tropicum* SATÔ
67. *Dendrostoma minor* IKEDA
68. *Dendrostoma signifer* SELENKA & DE MAN
69. *Dendrostoma blandum* SELENKA & DE MAN
70. *Dendrostoma hexadactylum* SATÔ
71. *Phascolion ikedai* SATÔ
72. *Phascolion dentalicola* SATÔ
73. *Phascolion rectus* IKEDA
74. *Phascolion artificiosus* IKEDA
75. *Phascolion lucifugax* SELENKA & DE MAN
76. *Aspidosiphon grandis*, n. sp.
77. *Aspidosiphon makoensis*, n. sp.
78. *Aspidosiphon formosanus*, n. sp.
79. *Aspidosiphon steenstrupii* DIESING
80. *Aspidosiphon elegans* (CHAMISSO & EYSENHARDT)
81. *Aspidosiphon carolinus* SATÔ
82. *Aspidosiphon truncatus* (KEFERSTEIN)
83. *Aspidosiphon angulatus* IKEDA
84. *Aspidosiphon mülleri* DIESING
85. *Aspidosiphon spinalis* IKEDA
86. *Aspidosiphon misakiensis* IKEDA
87. *Lithacrosiphon uniscutatus* (IKEDA)
88. *Cloeosiphon aspergillum* (QUATREFAGES)

PRIAPULOIDEA

89. *Priapulus caudatus* LAMARK
90. *Priapulus bicaudatus* DANIELSSEN

II. DESCRIPTION OF THE SPECIES

A. ECHIUROIDEA

Genus URECHIS Seitz

Prae-oral proboscis short, scoop-shaped. Two ventral setae exist close to and behind the mouth, and a circle of anal setae surrounds the anus. Two or three pairs of nephridia (gonoducts), each provided with two long spiral extensions of the lips of the coelomic aperture. Alimentary canal long, convoluted. A spacious rectum which serves as a respiratory organ, is led to a muscular cloaca. Two anal vesicles are attached to the cloaca at its ventro-lateral surface. No definite blood-system is present.

1. Urechis unicinctus (Von Drasche)
(Pl. XXII, Figs. 26-27)

Ein Echiuroid, Willemoes-suhm, 1876, p. 102.
Echiurus unicinctus, von Drasche, 1881, pp, 3-5, Pl. XX, Fig. 1; Selenka, 1885, pp. 6-7, Pls. I and III; W. Fischer, 1895, p. 21; A. Shipley, 1899, p. 344; A. Embleton, 1900, pp. 77-97, Pls. VII-X, Text-fig. 1; I. Ikeda, 1904, pp. 59-60; 1924, p. 38; A. Ostroumov, 1909, p. 319; J. Spengel, 1921, p. 356.
Urechis unicinctus, Seitz, 1907, p. 30; J. Spengel, 1912, pp. 173-212; W. Fischer, 1914, pp. 1-28; 1921, p. 423; H. Satô, 1931, pp. 171-178, Text-figs. 1-3; 1934, pp. 247-249, Text-fig. 1; 1937, pp. 141-142, Pl. II, Fig. 1.
Spiroctetor unicinctus, A. Skorikov, 1909, pp. 77-102.

This species is very common and is obtainable abundantly everywhere along the coast of Japan. The fishermen use this animal as bait. In Korea, the natives catch it by means of iron hooks and dry it for food as shown in Pl. XXII, Fig. 27.

Only three species are hitherto known of the genus *Urechis:* They are *Urechis unicinctus* (VON DRASCHE), *Urechis chilensis* (M. MÜLLER) and *Urechis caupo* FISCHER. *Urechis unicinctus* may be easily distinguished from the other two species by the number of the nephridia (gonoducts or segmental organs). It bears only two pairs of these organs, while the others carry three pairs.

Distribution :

In Japan :　Hokkaidô ; Northeast Honsyû (Matukawaura, Miyato-zima, Onagawa, Takada, Miyako, Moura, Nonai, Asamusi) ; Honsyû (Inage, Haneda, Tateyama, Hirosima, Tomo, Onomiti, Ôsaka Bay, Inland Sea) ; Sikoku ; Kiûsyû (Hukuoka) ; Korea (Reisui, Moppo, Seisin, Wandô).

Foreign :　Russia ; Amurland ; De Castries Bay.

Genus ECHIURUS PALLAS

Prae-oral proboscis long, spatula-shaped. Ventral setae exist ca. 10 mm behind the mouth. Double circlets of anal setae surround the anus. From one to three pairs of nephridia (gonoducts), each devoids of long spiral appendages. Blood vessels are well developed. No spacious rectum which serves as a respiratory organ.

2.　Echiurus echiurus (PALLAS)

Lumbricus echiurus PALLAS, 1774, Miscellanea Zoologica, p. 146, Pl. XI, Fig. 1–6. Spicilegia Zoolog., Tom. I, Fasc X, Tab. I, Fig. 1–5.

Echiurus forcipatus FABRICIUS, 1780, Fauna Groenlandica, p. 357.

Echiurus lütkeni DIESING, 1859, Revision der Rhyngodeen, p. 61.

Echiurus pallasi GUELIN, GREEFF, 1879, pp. 136–143 ; SPENGEL, 1879, pp. 542–547 ; 1880, pp. 460–524, Taf. XXIII–XXVI ; RIETCH, 1886, pp. 187–188 ; FISCHER, 1895, p. 21 ; AUGENER, 1903, pp. 297–371 ; IKEDA, 1924, p. 39, Fig. 12.

Echiurus echiurus (PALLAS), SPENGEL, 1912, pp. 173–212 ; FISCHER, 1914, pp. 1–28 ; 1921, p. 422 ; 1928, p. 478 ; CUÉNOT, 1922, p. 21.

Body measuring about 110 mm in length and 25 mm in thickness. The skin-papillae are arranged in more or less regular ring-rows. The number of anal setae is 11 in the anterior row, and is 8 in the posterior row. There are two pairs of nephridia. Anal vesicles are brown in colour. They are very long without any branches.

Distribution :

In Japan :　Okhotsk Sea ; Kuril Islands ; Hokkaidô.

Foreign :　Greenland ; Island ; Norway ; Murman-Küste ; Siberian Ice-sea ; Bering-Sea ; Aleutian ; Alaska ; Dänmark ; Scandinavia ; England,

Belgie; Normandie; Kanal la Manche; Nordsee; Skagerrak; Kattegat; Sund; East coast of North America.

Remarks: According to I. IKEDA (1924, p. 39), the present species has been obtained from the stomach of a cod (*Gadus macrocephalus*) caught somewhere in the Okhotsk Sea. Similar facts have been also recorded by other workers viz. BENHAM (1904) obtained one specimen of *Phascolosoma novae-zealandiae* from the stomach of a dog-fish (*Mustelus antarcticus*); SOUTHERN (1913) found one specimen of *Thalassema lankesteri* in the stomach of a dab (*Pleuronectes limanda*) taken from Kenmare River in Ireland.

Genus ARHYNCHITE SATÔ

Without proboscis. Two ventral setae exist close to and behind the mouth. No anal setae. Dermal musculature forms a continuous sheet. A pair of nephridia (gonoducts), each of which is provided with a leaf-life appendage. Blood vessels are well developed.

3. Arhynchite arhynchite (IKEDA)

Thalassema arhynchite IKEDA, 1924, pp. 41–42, Pl. I, Figs. 16-17.
Arhynchite arhynchite (IKEDA), SATÔ, 1937, pp. 143–145, Pl. II, Fig. 3, Text-fig. 2.

Body is about 135 mm long and 15 mm wide. Skin thick, entirely opaque, and is brownish-violet in colour when preserved in alcohol. The surface of the body-wall is covered with numerous skin-papillae. They are so small and low that the skin appears almost smooth to the unaided eye. The skin-papillae found at both ends of the body, however, are somewhat larger and slightly elevated.

The proboscis is entirely absent, and both ends of the body are rounded in a quite similar manner. On each side of the ventral median line and slightly behind the mouth, there exist a pair of small ventral setae. The anal setae are absent. Thus the anterior end of the body may be distinguished from the posterior only by the presence of the ventral setae mentioned above.

The dermal musculature forms a continuous sheet. There are only a pair of nephridia lying shortly behind the ventral setae. Each nephridium is a small elongated and thin-walled sac, and its internal aperture is provided with a single leaf-like appendage. The basal portion of the ventral setae is supported by numerous radiating muscles, and is connected with each other by a long slender interbasal muscle. The vascular system

consists of the ventral, dorsal and neuro-intestinal vessels. A pair of anal vesicles are present being attached to the rectum near the anus.

Distribution: Samé in Aomori prefecture; Hokkaidô.

Remarks: This species was described for the first time by the late Professor IKEDA (1924, pp. 41–42) to be belonged to the genus *Thalassema.* He has stated in his description as follows: " The following description of this new species is based on the numerous specimens preserved in the Fisheries School at Sapporo..... The striking peculiarity is the absence of the proboscis. I carefully examined at Sapporo all the specimens in order to ascertain if the proboscis had been detached from the body-proper, an accident often happening in many forms of echiuroids. But this is certainly not the case in the present instance ".

The writer also examined precisely the anterior portion of the body by cutting into serial sections and thus tried to ascertain whether the proboscis exists or not, or it was detached by some accident. But, as already mentioned in the above description, no trace of the detached proboscis was found, the mouth opening being entirely encircled by means of many papillae which are regularly arranged around it.

As to the internal structure, this species fundamentally resembles the members of the genus *Thalassema*, excepting for the presence of the leaf-like appendages found on the gonoducts.

The absence of proboscis, however, is a peculiar feature not only for the present species but also for the echiuroid as a whole, in fact we have hitherto no records of the echiuroids which do not bear proboscis.

From the reasons mentioned above, the genus *Arhynchite* has been newly established by the writer to receive this species in 1937 (pp. 142–143).

Genus THALASSEMA LAMARCK

Prae-oral proboscis long, spatula-shaped or tape-shaped. Ventral setae are present, but devoid of anal setae. Nephridia are 1–7 pairs. Blood vessels are well developed. The longitudinal muscle layer of the body-wall is of uniform thickness throughout, and the oblique muscle layer is also of uniform thickness and completely covers the longitudinal muscle layer.

4. Thalassema sabinum LANCHESTER
(Pl. XXII, Fig. 29; Text-figs. 3–5)

Thalassema sabinum LANCHESTER, 1905, pp. 40–41, Pl. II, Fig. 5; PRASHAD, 1919, pp. 321–338, Pl. XI, Figs. 2, 10, 15, Text-fig. 1; SATÔ, 1934, pp. 250–251, Figs. 4–6.

The main characteristics of this species given by LANCHESTER (1905) are as follows: — "The animal is small, measuring in one instance 10 mm, of which the proboscis forms only the fifth part, i. e. 2 mm.   The ventral setae lie close up behind the proboscis.   The skin is rather thin, and only partially transparent so far as concerns most of the internal organs, but the nerve-cord is clearly visible from the outside.   The proboscis is short as compared with the body.   There are two pairs of nephridia with spiral openings.   The muscle-sheath is continuous.   The anal trees are short."
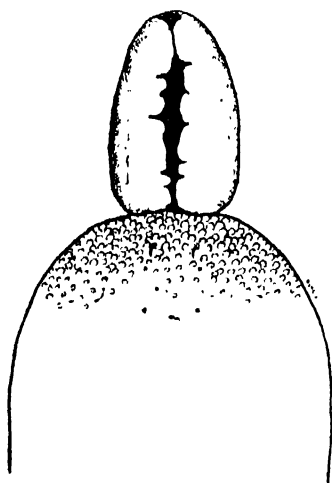
Text-fig. 3. *Thalassema sabinum* LANCHESTER. Anterior portion of the body with proboscis (ventral view). ×3.

Text-fig. 5. *Thalassema sabinum* LANCHESTER. A faece in the hind gut (side view). ×18.

Text-fig. 4. *Thalassema sabinum* LANCHESTER. Ventral seta (side view). ×18.

Distribution:

In Japan: Onomiti Bay; Zinsen in Korea.

Foreign: Malay Peninsula.

Remarks: Among the members of the genus *Thalassema*, there exist the following seven species that have two pairs of nephridia. They are *Thalassema sabinum*, *Thalassema marshalli*, *Thalassema microrhynchus*, *Thalassema branchiorhynchus*, *Thalassema dendrorhynchus*, *Thalassema neptuni* and *Thalassema semoni*.

The present specimens taken from Onomiti Bay and from Zinsen seem to be most closely allied to *Thalassema sabinum* in external features as well as in the internal anatomy.

5. Thalassema owstoni IKEDA

Thalassema owstoni IKEDA, 1904, pp. 62–63, Pl. I, Fig. 18; Pl. IV, Figs. 96–97; SATÔ, 1934, p. 249, Figs. 2–3.

Thalassema sp. TAMURA, 1930, p. 7, Pl. III, Fig. 4.

This species was first described by IKEDA (1904, pp. 62–63) using a single specimen dredged by OWSTON from a depth of 180 fathoms in the Uraga Channel. Afterwards, it was obtained abundantly from the shallow beach of Onomiti Bay by the writer himself and by the following collectors viz. Mr. M. TAMURA, Mr. T. MORI and Mr. K. ISIKAWA.

Comparing the specimens from Onomiti Bay with the type specimen, there are found some differences in dimension among them, as shown in the following table.

TABLE I.

	Body-length	Body-width	Proboscis-length
Type specimen	17 mm	5 mm	7.5 mm
Specimens from Onomiti Bay	30–80 mm	10–20 mm	20–45 mm

Distribution: Uraga Channel; Onomiti Bay. .

6. Thalassema fuscum IKEDA

Thalassema fuscum IKEDA, 1904, pp. 69–70, Figs. 21 & 99.

Distribution: No record.

7. Thalassema inansense IKEDA

Thalassema inansense IKEDA, 1904, p. 71, Figs 22 & 100.

Distribution: A coral reef, called Inanse, about three miles off Naha in Riukiu Islands.

8. Thalassema mucosum IKEDA

(Pl. XXII, Fig. 28; Text-figs. 6-7)

Thalassema mucosum IKEDA, 1904, pp. 68-69, Figs. 20 & 98.

Many specimens were obtained from the muddy shore of Wandô in Korea. In the living state, the body is cylindrical in form, measuring about 120 mm long and 20-30 mm thick in the larger specimens. The proboscis which has a truncated apex, is much shorter and narrower than the body.

The body-wall is thin and is of a light green colour, becoming deeper towards the both extremities. The skin-papillae are rather large, being visible to the naked eye. In the fresh state, the body-surface always appears dirty owing to thick mucus spread over.

The ventral setae (Text-fig. 6) are two in number. They are very small, measuring about 3 mm in length, and is slightly curved at the tip.

The longitudinal and circular muscle layers of the dermal · musculature are not divided into bundles. There are three pairs of nephridia. They are very short and small, being located behind the ventral setae.

Text-fig. 6.
Thalassema mucosum
IKEDA. Ventral seta
(side view). ×18.
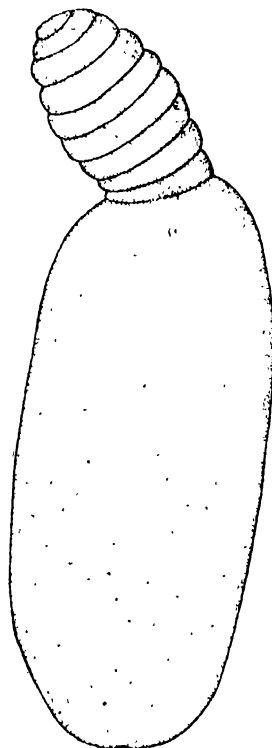
Text-fig. 7. *Thalassema mucosum* IKEDA. A faece obtained from the hind-gut (side view). ×18.

The faeces contained in the hind-gut are of very large size, measuring about 8.3 mm in length and 2.8 mm in width. Each of these shows a peculiar form of a pellet-like manner (Text-fig. 7).

Distribution: Misaki; Wandô (in Korea).

Remarks: This species was described for the first time by the late Prof. I. IKEDA in 1904, the specimen being taken from Misaki.

As noted in the present description, the form of faeces is very peculiar of this species. In Echiuroidea, the form of the faeces is peculiar to one species, and thus they are different in different species. For instance, in *Thalassema mucosum* the faeces are very large in size, measuring 8.3 mm long and 2.8 mm wide, and each of which shows the peculiar form of a pellet-shaped as indicated in the Text-fig. 7. In *Thalassema sabinum*, on the contrary, the faeces are very small, measuring about 1.5 mm long and 0.5–0.6 mm wide, and have a form of short cylinder as shown in Text-fig. 5.

9. Thalassema elegans IKEDA

Thalassema elegans IKEDA, 1904, pp. 65–66; 1907, pp. 47–55; Pl. I, Fig. 4, Pl. IV, Figs. 48–49.

Distribution: Moroiso (close to the Misaki Marine Laboratory).

10. Thalassema gogoshimense IKEDA

Thalassema gogoshimense IKEDA, pp. 66–67, Fig. 19; SATÔ, 1934, pp. 251–252, Figs. 7–8.

This species very closely resembles *Thalassema mucosum* both in colour and external form, with the exception of the facts that the body is much larger and the papillary spots are more deeply tinged with dirty green. Internally, there are some differences between these two species in the shape of the ventral setae (SATÔ, 1934, Fig. 8; and Text-fig. 6 in this paper) as well as in the number of the nephridia.

This species is obtainable abundantly in Onomiti Bay together with *Thalassema owstoni* and *Thalassema sabinum*. These three species, mentioned above, are used by the fishermen as bait.

Distribution: Gogo-sima (Sikoku); Onomiti Bay; Moroiso (Misaki).

Genus IKEDA WHARTON

Nephridia, provided with terminal funnels, are variable in number, and are not arranged in pairs; longitudinal muscle layer of the body-wall always lying outside of both the circular and oblique muscle layers.

11. Ikeda taenioides (IKEDA)

Thalassema taenioides IKEDA, 1904, pp. 63–64; 1907, pp. 16–47, Pl. I, Fig. 3, Pl. II, Figs. 18–22, Pl. III, Figs. 23–36, Pl. IV, Figs. 37–47.

Ikeda taenioides (IKEDA), WHARTON, 1913, pp. 243–270; SATÔ, 1931, pp. 179–180, Text-
fig. 4; 1934, p. 252, Fig. 9; 1937, p. 142, Pl II, Fig. 2.

This extremely interesting echiuroid was described for the first time by the late Prof. I. IKEDA from Sagami Bay, in the name of *Thalassema taenioides*. Afterwards, the species was transfered from the genus *Thalassema* into the genus IKEDA which was first erected by WHARTON in 1913.

This species occurrs along the Pacific coast of Japan proper: from Amakusa in the south to Mutsu Bay in the north.

In both of Mutsu Bay and Onagawa Bay, several pieces of the proboscis were collected from the muddy bottom of 3–6 fathoms depth. They are long, and flat, being band-like in form, measuring up to 600 mm in length and is 5–7 mm wide when fully extended; while they become much shorter when they contract.

Distribution: Sagami Bay; Tusima; Amakusa; Tomo; Inland Sea; Tateyama; Haneda; Onomiti Bay; Onagawa; Mutsu Bay.

Genus OCHETOSTOMA LEUCKART & RÜPPELL

The main part of the longitudinal muscle is interrupted by intervals, so that longitudinal bundles are formed which appear to be separated, but are in reality connected by a thin layer of longitudinal fibres existing between the bundles. The oblique muscle does not follow the longitudinal layer in the intervals, but bridges the intervals on septal bands of connective tissue.

12. Ochetostoma erythrogrammon (LEUCKART & RÜPPELL)
(Pl. XIX, Figs. 1–2, Pl. XXII, Fig. 30; Text-figs. 8 9)

Ochetostoma erythrogrammon, LEUCKART & RÜPPELL, 1828, Neue wirbellose Tiere des
Roten Meeres. Atlas z. Reise i. nördl. Afrika, Abt. Zool., pp. 7–8; SPENGEL,
1912, pp. 309–317; FISCHER, 1926, pp. 109–116; SATÔ, 1935, p. 324.
Thalassema erythrogrammon, DRASCHE, 1881, pp. 6–9.
Thalassema caudex, LAMPERT, 1883; SHIPLEY, 1898.
Thalassema kokotoniense, FISCHER, 1892, p. 82; 1895, p. 20; 1914, pp. 1–28; SHIPLEY,
1899, p. 337; IKEDA, 1904, p. 60.
Thalassema stuhlmanni, FISCHER, 1892, p. 82; 1895, p. 20; 1914, pp. 1–28; AUGENER,
1903, pp. 297–371.
Thalassema leptodermon, FISCHER, 1892, pp. 84–85; AUGENER, 1903, pp. 297–371.
Thalassema palense, IKEDA, 1924, pp. 39–41.

Numerous specimens of this tropical species were collected in various localities shown in the following: Hôko-tô, Daihanratu and Hattosi in Formosa; Saisyû-tô in Korea; Naha in Riukiu Islands.

Of these specimens, mentioned above, the largest one which was secured from Hôko-tô by Mr. HARADA (Pl. XIX, Fig. 2) measures about 65 mm in body-length and is about 15 mm in body-breadth; while the smallest one from Riukiu Islands is only about 25 mm long and 8 mm broad.

In the fresh state, the skin of the animal appears beautifully bluish green; but it becomes dirty gray when preserved in alcohol. The skin is generally thin and somewhat translucent, but in the region of both extremities of the body it becomes more or less thicker and opaque.

The proboscis long, being nearly as long as the body-length when fully expanded.

Text-fig. 8. Ochetostoma erythrogrammon (LEUCKART & RÜPPELL). Ventral seta (side view). ×18.
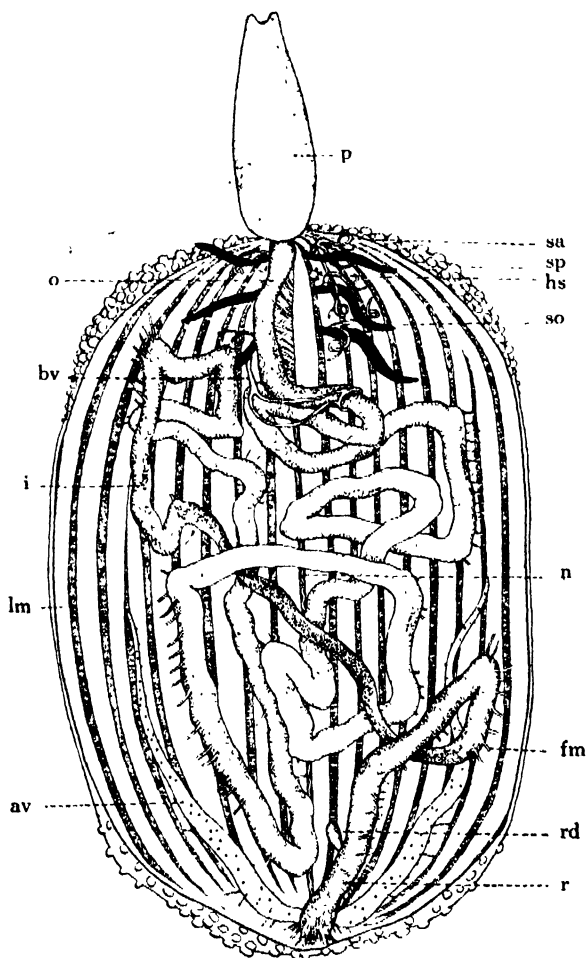
Text-fig. 9. Ochetostoma erythrogrammon (LEUCKART & RÜPPELL). Specimen dissected. av, anal vesicle; bv, blood-vessel; fm, fixing-muscle; hs, hook-sheath; i, intestine; lm, longitudinal muscle-band; n, ventral nerve-cord; o, oesophagus; p, proboscis; r, rectum; rd, rectal diverticulum; sa, spiral appendage; sp, skin-papilla; so, segmental organ. (Natural size).

The surface of the body-wall is covered with numerous skin-papillae. They are relatively minute and are irregularly distributed over the main part of the skin-surface, but at both ends of the body the skin-papillae are much larger and taller being more closely crowded. The two ventral setae (Text-fig. 8), are so minute that they are hardly visible with the naked eye, and are located about 2 mm behind the proboscis-basis. No anal setae are present.

As to the internal anatomy, it may be mentioned in the first place that the longitudinal dermal musculature appears to be separated, forming 14 bundles. No interbasal muscle between the two ventral setae (Text-fig. 9). There are three pairs of nephridia (Text-fig. 9, so), the first pair in front of, and the other two pairs behind the ventral setae (Text-fig. 9). Each of the nephridia is in the form of a sac provided with two short and slightly coiled spiral appendages (Text-fig. 9, sa). The alimentary canal (Text-fig. 9, i) is a long coiled tube fastened to the body-wall by means of numerous fixing-muscles (Text-fig. 9, f). The rectum sends out two large anal vesicles (Text-fig. 9, a) extending forwards beyond the middle of the body. They are provided with comparatively few and very small unstalked funnels. A single rectal gland is present upon the rectum.

Distribution :

In Japan : Palau; Yap; Formosa; Riukiu Islands; Amami-Osima; Korea.

Foreign : Red Sea; Kosseir; Indian Ocean; Mauritius; Reunion of Bourbon; Obi-major Riff; Amboina; Pacific Ocean.

Genus LISTRIOLOBUS Spengel

The longitudinal muscle layer of the body-wall is thickened into bundles at intervals, and is not interrupted between the bundles, but simply becomes thinner, forming undurations.

13. Listriolobus riukiuensis, n. sp.
Text-figs. 10-13

Only a single specimen (type specimen) representing a very interesting new species, was collected by Prof. Dr. H. OHSHIMA, at the sea-shore of Kabira of Isigaki-zima on Feb. 26, 1937.

The specimen was well preserved in alcohol, and the proboscis is completely preserved in an expanded condition. The body of this specimen,

however, to the writer's reglet, is damaged in its posterior part. Thus, the total length of the body is not able to be mentioned here.

Text-fig. 10. *Listriolobus riukiuensis*, n. sp. Natural size.

Text-fig. 11. *Listriolobus riukiuensis*, n. sp. Ventral seta (side view). ×50.

The remaining part of the body is elongated cylindrical (Text-fig. 10), and measures about 75 mm in length and 8 mm in width. It is pinkish-gray colour in preserved state, and is beset with numerous skin-papillae. The skin-papillae found in the anterior region are rather elevated and are easily visible to the naked eye.

The proboscis is band-like and is remarkably long, being about 130 mm in length and 10 mm in width. In cross section, it appears crescentic, the concave side of which facing ventrally.

The ventral setae (Text-fig. 11) are situated near the anterior end of the body at about 8 mm distance from the mouth-aperture. They are very small, being about 2.7 mm in length. The radial muscles of the setae are very weakly developed, and no inter-basal muscle is stretched between the two setae (Text-fig. 12).

There are three pairs of nephridia, the anterior most of which exists in front of the ventral setae (Text-fig. 12). Each of the nephridia is in form of an elongated small vesicle with two spiral lobes at the internal opening. The blood-vessels are well developed (Text-fig. 13, bv). The alimentary canal is filled up with coral sand mixed with various tiny molluscan shells. The posterior part of the canal has been torn off, and it was not able to observe the features of anal vesicles.

The dermal muscle layer consists of three parts (Text-fig. 13). The outermost is made up of circularly arranged fibres (Text-fig. 13, cm); the middle is of the longitudinal (Text-fig. 13, lm); and the innermost is of the oblique (Text-fig. 13, om). Of these three layers, mentioned above, the longitudinal muscle layer is thickened into bundles at intervals, and is not interrupted between the bundles, but simply becomes thinner, forming undulations (Text-fig. 13). The bundles are twelve in number.

Distribution: Kabira in Isigaki-zima (Riukiu Islands).

Remarks: SPENGEL (1912) has studied the dermal muscle layer of all of these forms belonging to the genus *Thalassema*, and on the basis of the difference seen in structure he has divided the genus *Thalassema* into
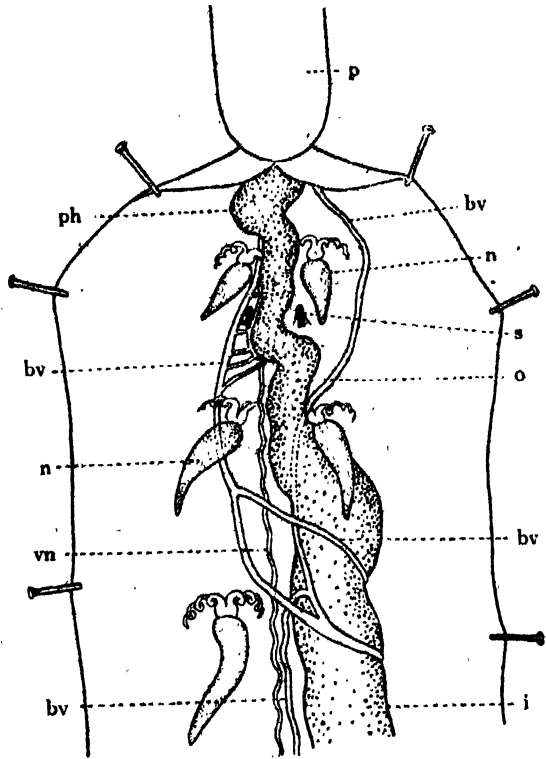
Text-fig. 12. *Listriolobus riukiuensis*, n. sp. Specimen dissected showing the anterior part of the body. bv, blood vessel; i, intestine; n, nephridium; o, oesophagus; p, proboscis; ph, pharynx: s. ventral seta; vn, ventral nerve-cord. ×4.
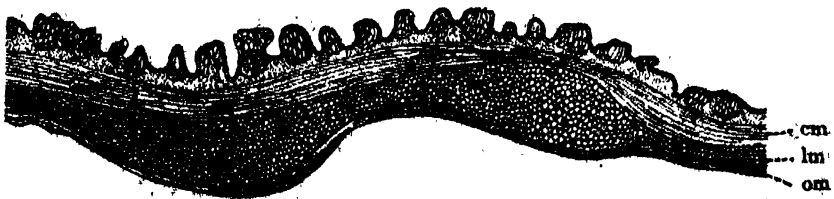
Text-fig. 13. *Listriolobus riukiuensis*, n. sp. Transverse section through the body-wall in the anterior portion of the worm. cm, circular muscle layer; lm, longitudinal muscle layer; om, oblique muscle layer. ×50.

the following three separate genera : viz. genus *Thalassema*, genus *Ocheto-stoma* and genus *Listriolobus*.

The first genus *Thalassema*, for which he has taken the species, *Thalassema neptuni* GAERTNER, as the type, has the following characteristics : The longitudinal muscle layer of body-wall is of uniform thickness throughout, and the oblique muscle is also of the uniform thickness and completely covers the longitudinal layer.

The second genus to which he gave the old generic name of LEUCKART & RÜPPELL, *Ochetostoma*. This genus is characterized in having the main part of the longitudinal muscle layer interrupted by intervals. The longitudinal muscles appear to be separated into bundles, but in reality these bundles are connected by a very thin layer of longitudinal muscle fibres found between the bundles. In this genus, he placed two species formaly called *Thalassema erythrogrammon* LEUCKART & RÜPPELL and *Thalassema caudex* LAMPERT.

To the third genus, he gave the name of *Listriolobus*. This genus is characterized as follows : The longitudinal muscle layer of the body-wall is thickened into bundles at intervals, and is not interrupted between the bundles, but simply becomes thinner, forming undulations. To this genus he has assigned *Thalassema erythrogrammon* of SLUITER (1883) and WILSON (1900) and the specimen of this species he has obtained from Florida.

As mentioned in the previous pages of this paper, the present species is furnished with the same characteristics as seen in the genus *Listriolobus*. But this new species is easily distinguished from other known members of the genus, in having a remarkably long proboscis.

Genus BONELLIA ROLANDO

Sexual dimorphism remarkably pronounced :

In the female, the body is large, oval-shaped, with a long proboscis which is bifurcated at apex. The colour is bluish-green or grayish brown. Ventral setae consist of a single pair or of numerous. Only one nephridium is present. Anal vesicles are branched.

The male is parasitic to the female, and the body is small, looking like Nematod or Turbellaria in shape.

14. **Bonellia fuliginosa** ROLANDO

Bonellia fuliginosa ROLANDO, 1821, Memorie della reale Academia delle science di

Torino XXVI, S. 539-551; FISCHER, 1895, p. 21; RIETSCH, 1886, p. 198;
IKEDA, 1924, pp. 42 43; BALTZER, 1931, 162.
Bonellia minor MARION, RIETSCH, 1886, p 198; IKEDA, 1904, pp. 72-73, Figs. 23, 101
& 102; CUÉNOT, 1922, p. 24; BALTZER, 1931, p. 162.

Distribution :

In Japan : Tateyama in the Prefecture of Tiba ; Kataura in the
Province of Satuma ; Naha in Riukiu Islands.

Foreign : Marseille ; Naples.

15. Bonellia miyajimai IKEDA

Bonellia miyajimai IKEDA, 1904, pp. 73 74; 1907, pp. 2-16, Pl. I, Figs. 1-2, Pl. II, Figs.
5-17.

The female : Body short, cylindrical, narrowed towards both ends.
Proboscis is very slender and about six times as long as the body.
Colour is grayish brown with minute blackish brown flecks. Ventral
setae numerous. Anal gland branched, bearing numerous stalked funnels.

The male : Found in the body-cavity of female. Unusually it is large
being nearly 30 mm long ; without ventral setae. Alimentary canal is
broken down into numerous vesicles. No nerve-ring is found. Vas de-
ferens is divided posteriorly into four branches, each ending with a ciliated
funnel.

This species markedly differs from *Bonellia fuliginosa* in the number
of ventral setae. The former bears a great number of ventral setae,
while the latter has only a single pair of the same.

Distribution : Tomari in Riukiu Islands.

Genus PROTOBONELLIA IKEDA

Proboscis long and tubular, not bifid. Body with two distinct ventral
setae, without anal setae. Single nephridium (gonoduct) with a long-
stalked and fimbriated funnel ; anal vesicles once branched before ending
into ciliated funnels ; Alimentary canal and blood-vessels well developed.

16. Protobonellia mitsukurii IKEDA

Protobonellia mitsukurii IKEDA, 1908, pp. 259 265, Figs. 1-4.

Distribution : Sagami Bay at a spot 300 fathoms deep.

Genus PARABONELLIA ONODA

The body is swollen and the long proboscis is bifurcated at the apex.

There are a single anterior nephridium (oviduct) and two anal vesicles provided with ciliated funnels. Ventral setae are entirely missing. The male is nematode-like, without mouth and anus.

17. Parabonellia misakiensis (IKEDA)

Bonellia misakiensis IKEDA, 1904, pp. 74–76, Figs. 24, 103–105.
Pseudobonellia misakiensis (IKEDA), ONODA, 1934, pp. 413–422, Pl. XX, Figs. 1-6, Text-figs. 1-3.
Parabonellia misakiensis (IKEDA), ONODA, 1935, p. 141; SATÔ, 1935, pp. 142–144, Figs. 1-2.

This species was described for the first time by the late Prof. I. IKEDA in 1904, in the name of *Bonellia misakiensis*, using a unique specimen collected at the shore of Zyôga-sima, Misaki. It was found under a large stone laid near the beach.

Recently in 1934, K. ONODA established a new genus *Pseudobonellia*, to receive IKEDA's *Bonellia misakiensis*. The specimens with which ONODA established the said new genus, were obtained at Goza, a small village near Hamazima, Sima Province. The generic name *Pseudobonellia*, however, was replaced afterwards by the same author (1935) with ' *Parabonellia* ', from the reason that *Pseudobonellia* has been preoccupied by T. H. JOHNSTON and O. W. TIEG (Proc. Linn. Soc. N. S. Wales, Vol. 44, 1919).

Distribution: Misaki; Goza; Simoda.

Genus ACANTHOHAMINGIA IKEDA

Female: The shape of the proboscis is much like that of *Thalassema*; the skin is thin and delicate in texture, with or without papillae, the genital opening lies in a narrow longitudinal groove of the skin (the genital groove), in which also lie crowded numerous ventral setae wanting the muscular sheath and radial muscles; the anal vesicles are more than two in number and are branched several times before ending in funnels; the nephridium (oviduct) is one and unpaired, with a stalked funnel.

Male: The body is long and slender, the whole surface being uniformly ciliated. No ventral setae is present; the spermatic duct is long and wide, with a single funnel opening into the body-cavity.

18. Acanthohamingia shiplei IKEDA

Acanthohamingia shiplei IKEKA, 1910, pp. 135–147, Pl. X, Figs. 1-9.

Distribution: Sagami Bay (at a depth of 400 fathoms).

19. Acanthohamingia ijimai (IKEDA)

Hamingia ijimai IKEDA, 1908, pp. 61–£8, Pl. I, Figs. 1–8.
Acanthohamingia ijimai (IKEDA), 1910, p. 147.

Distribution: Sagami Bay (at a depth of 500 fathoms).

B. SIPUNCULOIDEA

Genus SIPUNCULUS LINNAEUS

Each of the longitudinal and circular muscle layer is separated into bundles. Leaf-like tentacles present around the mouth. Hooks absent. Four retractor muscles present. Intestinal convolution coils spirally around the spindle-muscle terminating free from the body-wall, and is fastened to the body-wall by means of numerous fixing-muscles arising from the latter. Two segmental organs exist. The polian canal run along the oesophagus. Integumental canal runs along each of the longitudinal muscle-bands. Triangular scale-like papillae are distributed on the introvert. -

20. Sipunculus nudus LINNAEUS
(Pls. XIX, XXII, Figs. 3, 31)

Sipunculus nudus LINNAEUS, 1766, Syst. Nat. 12th edit. p. 1078; KEFERSTEIN, 1860, p. 1; 1865, pp. 418-419; 1867, pp. 44-45; BAIRD, 1868, p. 77, ANDREAE, 1881, pp. 477-481; 1882, pp. 201-258, Pls. XII–XIII; SELENKA, 1883-1881, p. 92; 1885, p. 22; WARD, 1891, pp. 143-182, Pls. I–III; SHIPLEY, 1893, p. 154; FISCHER, 1895, p. 9; 1914, pp. 1-28; 1922, p. 5, Pl. XXVI, Figs. 5-6; ME-TALNIKOFF, 1900, pp. 261-322, Pls. XVII-XXII; SLUITER, 1902, p. 5; AUGENER, 1903, pp. 297-371; IKEDA, 1904, p. 31; 1905, p. 169; SOUTHERN, 1913, pp. 1-46; GEROULD, 1913, p. 428; CHAMBERLIN, 1920, p. 30; CUÉNOT, 1922, p. 14; 1927, p. 249; TEN BROEKE, 1925, p. 2; SATÒ, 1930, pp. 2-5, Pl. I, Fig. 1, Text-fig. 1; 1934, pp. 1-2, Pl. I, Fig. 1; 1935, pp. 300-301; 1937, pp. 145-146; STIASNY, 1930, p. 207; WESENBERG-LUND, 1933, pp. 11-12.

The surface of the body-wall excluding of the introvert is closely beset with small rectangular areas which are formed by the intersection of both the longitudinal and the circular muscle-bands. The skin is thin but entirely opaque. The introvert is covered with numerous scales looking like papillae. They are triangular in surface view and their vertices are directed posteriorly. Neither hook nor spine is found on the introvert. The tentacular crown consists of a pair of (right and left) lobes.

The longitudinal muscle layer of the body-wall is divided into 28–33 separate bands which do not anastomose except in the anterior region of the trunk. In the region of the introvert they are fused together forming a continuous sheet. The circular muscle layer is also divided into numerous narrow bands. Two pairs of short retractor muscles arise at the same level from the inside of the body-wall. The ventral pair are attached to the 2nd–5th longitudinal muscle-bands, while the dorsal pair are connected to the 9th–12th of the same. A spindle-muscle which arise in front of the anus, is not fixed posteriorly to the body-wall. Numerous fixing-muscles arising from the body-wall, are attached to the intestinal convolution. The intestinal convolution consists of about 15 spirals. The polian canals pass along the dorsal and the ventral sides of the oesophagus. They are simple and have not any villus arising from them. A pair of tuft-like organs exist near the anus arising from both sides of the rectum and are fastened to the body-wall by means of the mesenteries. The segmental organ consists of a pair of tubes of about 20 mm long and of a yellowish-gray colour. The anterior one-fifth of their length is fixed to the body-wall by means of a number of mesenteries. Their external openings lie between the 4th and 5th longitudinal muscle-bands at a level far distant from the anus. The ventral nerve-cord is not closely attached to the skin in the anterior region of the body. No eye-spot is detected on the cerebral ganglion.

Distribution :

In Japan : Misaki ; Tateyama ; Inland Sea ; Mutsu Bay ; Muroto-zaki ; Sata-misaki ; Reisui and Tôei (Korea) ; Hôko-tô (Formosa) ; Yap Island.

Foreign : From foreign waters, the species has been taken at the following localities : Mediterranean Sea ; North Sea ; Red Sea ; Indian Ocean ; Adriatic Sea ; Along the southern coast of the United States of America ; Panama ; Spain ; Istria ; China ; South Australia.

Remarks : From Formosa, four specimens of this species were obtained. Of which, two were collected at Hôko-to on June 10th 1930, by Mr. I. HARADA, Assistant-professor of the Taihoku Imperial University ; while the remaining two were obtained by the writer himself in the same locality on March 25th 1936. Of these four specimens, mentioned above, the largest one (Pl. XIX, Fig. 3) which was collected by Mr. HARADA, measures about 90 mm in body-length and 6–8 mm in thickness of the body. The introvert is about 20 mm long.

The collection made in Korea contains three specimens of this species. Of these three specimens, the two were obtained by the writer at the

coast of Reisui on Sept. 7th 1937; while the remaining one was secured
from Tôei by Mr. T. KAMITA of the Keizyô Normal School. The speci-
mens from Reisui are about 120 mm in total body-length and is about
10 mm in thickness of body. The introvert which is much narrower than
the trunk is about 15 mm long. The specimen from Tôei is much slender
than those from Reisui, measuring about 140 mm in total body-length
and about 7 mm in thickness of body (Pl. XXII, Fig. 31). In the speci-
men from Tôei, the longitudinal muscle-bands are comparatively small in
number, counting 28 in the middle region of the trunk and 29 in the
anterior region.

21. Sipunculus indicus PETERS
(Pl. XIX, Fig. 4)

Sipunculus saccatus, LINNAEUS. Systema Naturae, Editio duodecima, Tom 1, Holmiae,
    1766, p. 1078.
Sipunculus indicus PETERS, 1850, Arch. f. Anat. u. Phys., pp. 382-385; KEFERSTEIN,
    1865, p. 196; SELENKA, 1884, pp. 111-112; BAIRD, 1868; SLUITER, 1898, p.
    445; 1902, p. 7; FISCHER, 1892, pp. 86-88; 1893, pp. 3-12; 1895, p. 8;
    LANCHESTER, 1905, p. 29.
Sipunculus discrepans SLUITER, SATÔ, 1935, pp. 302-303.

A single specimen was taken in the coral sand at the beach of Hattosi
in Formosa on March 28th, 1936.

The body is elongate cylindrical in form and is nearly uniformly thick.
The trunk measures about 24 mm in length and its diameter is about
8 mm. The posterior end of the trunk is slightly swollen and terminates
in the form of a truncated cone. The introvert is considerably short
measuring only about 10 mm, and is covered with numerous scale-like
papillae. The colour of the skin, in the fresh state, is pinkish-white.
The surface of the trunk is divided into a large number of square areas.
These areas are thus far produced by the intersection of the longitudinal
and the circular muscle-bands both lying inside of the skin. In the pre-
served specimen, each of these areas appears roundish hexagonal in form
in the middle region of the trunk.

The longitudinal muscle layer of the body-wall is divided into 37
separate bands. The circular muscle layer is also divided into a large
number of muscle-strands. The retractor muscles are of two pairs, arising
at about the same level placed 20 mm behind the external apertures of
the segmental organs. Of these two pairs, the ventral pair arise from
the 2nd–4th longitudinal muscle-bands, while the dorsal pair arise from

the 10th–12th of the same. A stout spindle-muscle springs from the ventral wall of the rectum near the roots of the dorsal retractor muscles, and runs into the intestinal convolution. There are numerous fixing-muscles on the inner surface of the body-wall, by means of which the intestinal convolution is fastened to the body-wall. The intestinal convolution consists of 25–30 spirals. The rectum bears a pair of broad wing-muscles which are attached near the anus. The rectal diverticulum is not found on the rectum. The polian canals are present upon the oesophagus. The segmental organ consists of a pair of long tubes. Each of these tubes is fixed by means of mesentery to the body-wall with its greater length.

Distribution:

In Japan: Hattosi in Formosa; Kayangaru in Palau Island.

Foreign: Mozambique; British East Africa.

Remarks: This species closely resembles *Sipunculus discrepans* SLUITER. In fact it was formally identified by the writer (1935, pp. 302–303) with the latter species.

According to SELENKA (1884, pp. 111–112), the longitudinal muscle layer of the body-wall is divided into 39–43 separate bands in the specimens from Mozambique and Palau. But, as already mentioned above, the present specimen from Formosa bears only 37 longitudinal muscle-bands.

22. Sipunculus robustus KEFERSTEIN

Sipunculus robustus KEFERSTEIN, 1865, p. 421; BAIRD, 1868, p. 80; SELENKA, 1883, p. 221; SELENKA et DE MAN, 1883–1884, p. 97, Pl. XII, Fig. 170; SLUITER, 1886, p. 481, Pl. II, Figs. 8–9; 1890, p. 122; 1902, p. 4; FISCHER, 1895, p. 7; 1922, p. 7; AUGENER, 1903, pp. 297–371; LANCHESTER, 1905, p. 27; TEN BROEKE, 1925, p. 2.

This huge sipunculid is very commonly found at the coral sand shore of Palau and Yap Islands.

In Palau Island I have had a chance to see the natives eating this animals and *Sipunculus indicus.*

Distribution:

In Japan: Palau and Yap Islands.

Foreign: Uwea; Wallis Island; the Mergui Archipelago; Barbados; Amboina; Timor; Lyly-Inseln; Billiton; Nusa-Lant; Upou; Marquesas; Sydney; Singapore; Spain.

Genus SIPHONOSOMA SPENGEL

The longitudinal muscle layer is separated into bands. The circular muscle layer is usually continuous. Filamentous tentacles encircle the mouth as in the case of the genus *Phascolosoma*. Four retractor muscles are present. The intestinal convolution is fastened to the body-wall at both ends of the trunk. At the anterior part of the intestinal convolution, there occur a small number of fixing-muscles. There are two segmental organs. The polian canal usually gives off numerous polian tubules. The integumental canals are cut into many isolated closed sacs, branched very irregularly. No triangular scale-like papillae are present on the introvert.

23. Siphonosoma cumanense (KEFERSTEIN)
(Pls. XXII-XXIII, Figs. 32-33)

Phascolosoma cumanense, KEFERSTEIN, 1867, pp. 53-54.
Phascolosoma semirugosum, GRUBE (SELENKA, 1883-1884, p. 104).
Sipunculus cumanensis (KEFERSTEIN), SELENKA, 1883-1884, pp. 104 107, Taf. XII, Figs. 172 -173; SLUITER, 1886. p. 486; 1890, p. 123; 1902, p. 4; FISCHER, 1892, p. 88; 1895, p. 9; 1914, p. 1; SHIPLEY, 1893, pp. 326 333; 1899 (1), p. 157; 1902, p. 135; AUGENER, 1903. pp. 297-371; IKEDA, 1904, pp. 32 35; LANCHESTER, 1905, p. 27; 1905, p. 29; 1905, p. 36.
Siphonosoma cumanense (KEFERSTEIN), SPENGEL, 1912, p. 263; GEROULD, 1913, pp. 432-435; SATÔ, 1934, pp. 246 -247; 1937, pp. 146-148, Pl. III, Fig. 8; STIASNY, 1930, p. 208, SHITAMORI, 1936, pp. 155 -175.

This species seems to be cosmopolitan having been obtained at many localities in the world.

The longitudinal muscle layer of the body-wall is mostly divided into 20 bands, but sometimes it is found that it has 18, 19, 21, 23 or 24, of the same as indicated in the Table II.

Concerning the number of longitudinal muscle-bands, it was also pointed out by IKEDA (1904, p. 43) saying: — "The longitudinal muscles are divided into 18–21 (mostly 20) separated bundles which very rarely anastomose".

Distribution: This species is widely distributed in Japan being obtained at many localities as shown in the Table II. From the waters of foreign countries it has been recorded from Gumana, Uhoy, Bohol, Amboina, Maldive Islands, Laccadive Islands, Singapore, Zanzibar, Neu-Pommern, Key West, Damar Island, Tiur Island, Salius Ketjil, Waigeu, Sanquisiapo, Lucipara, Sapeh Bay, Kokotoni, Nossi Bay, Mauritius, West Java and Loseir.

TABLE II

Localities in Japan and the number of longitudinal muscle-bands of Siphonosoma cumanense.

	Localities	No. of lon. mus.
North Japan	Matukawa-ura	20
	Kobuti	20
	Miyato-zima	20
	Izu-sima	20
	Koamikura	23
	Karakuwa	20
	Mutsu Bay	20
	Hirasawa	23–24
	Kisagata	20
	Kamô	20–21
	Nezugaseki	20
Middle Japan	Tôkyô Bay	20
	Ôsaka Bay	20
	Onomiti	19 –20
	Hirosima	20
	Fukuoka	20
	Kagosima	20
South Japan	Naha (Riukiu Island)	20
	Daizyu-bô (Formosa)	20
	Palau	20
	Yap	20
Korea	Reisui	20
	Gunzan	20
	Zyôsin	20
	Genzan	20
	Saisyû-tô	18

Remarks: *Siphonosoma cumanense* was originally described by KEFERSTEIN in the name of *Phascolosoma cumanense.* Afterward, in 1883–1884, three varieties of this species have been established by SELENKA & DE MAN. They are *Siphonosoma cumanense* var. *vitrea,* *Siphonosoma cumanense* var. *opaca,* and *Siphonosoma cumanense* var. *semirugosa.* Of these three varieties mentioned above, the first has been obtained by the writer in 1935 from the sandy shores in Palau and Yap Islands. It is very slender, and the skin is colourless being thin and translucent. The majority of the specimens of this species taken from Japanese waters, are to be belonged to the second variety. In the second variety, the skin is extremely thick and is entirely opaque. The third variety has not yet been found in Japan.

24. Siphonosoma mourense SATÔ

Siphonosoma mourense SATÔ, 1930, pp. 6–8, Pl. I, Figs. 2 4; 1937, pp. 148–149, Pl. III, Fig. 9.

This species which was first described from Mutsu Bay by the writer in 1930, closely resembles *Siphonosoma cumanense* in external features,

but it may be easily distinguished from the latter by the absence of crescent-shaped dissepiments as well as by the position of the attachment-base of the retractor muscles.   In *Siphonosoma cumanense* the longitudinal muscle layer of the body-wall is divided into 20 bands, while in the present species it is divided into 22.

Distribution :   Moura and Asamushi (in Mutsu Bay) ; Karakuwa and Miyato-zima (in Miyagi prefecture).

25. Siphonosoma amamiense (IKEDA)

Sipunculus amamiensis IKEDA, 1904, pp. 36–38, Figs. 64–65.

A single specimen was found in coral sand at Miyako in Riukiu Island on April 5th 1936.

The trunk measures about 160 mm in length and 6–8 mm in thickness, and the length of the introvert is about one-fourth that of the trunk. In the preserved specimen in alcohol, the colour is yellowish gray in the main part of the trunk and is deep brownish yellow in the introvert. The skin-surface is rough, especially at the introvert-basis, being covered with the largest skin-papillae of dark yellow colour.   Hooks or spines are absent on the introvert.

The longitudinal muscle layer of the body-wall is divided into 15–16 broad bands which rarely anastomose.   Four retractor muscles are present. The roots of the dorsal pair are situated far more anteriorly than those of the ventral pair.

Distribution :   Koniya (Amami-Ôsima) ; Naha and Miyako (Riukiu Island).

Remarks :   This tropical species was described for the first time by the late Professor IKEDA in 1904 from Koniya in Amami-Ôsima and Naha in Riukiu Island, and this is the second report on this species.

26. Siphonosoma edule SLUITER
(Pl. XX, Fig. 6)

Sipunculus edulis (LAMARCK), SLUITER, 1881, pp. 148–150, Pl. I, II, III, 1882, pp. 12–14; 1886, pp. 484–485; 1890, p. 122; 1902, p. 5; SHIPLEY, 1899, pp. 157–158; LANCHESTER, 1905, p. 29.
Siphonosoma edule SLUITER, SPENGEL, 1912, p. 263; GEROULD, 1913, p. 432; FISCHER, 1926, p. 106.

Only two specimens were placed at the writer's disposal.   Of the two, mentioned above, the one was obtained at the beach of Hattosi in Formosa and the remaining one was found near the shore in coral sand

at Miyako in Riukiu Islands.

In the specimen from Formosa, the trunk measures about 80 mm in length and about 8 mm in thickness. The introvert is about one-eighth of the trunk in length. The specimen from Korea is much larger in size than that from Formosa, being about 200 mm long.

Neither hook nor spine is found upon the introvert. Tentacles are filamentous and are numerous in number.

The longitudinal muscle layer of the body-wall is divided into 20–21 separate bands, but in the region of the introvert they fuse together to form a continuous sheet. Two pairs of the retractor muscles are present. The ventral pair are broader than the dorsal arising from the 1st–3rd longitudinal muscle bands, while the dorsal pair arise from the 7th–8th of the muscles. The roots of these four retractor muscles are situated at nearly the same level. A stout spindle-muscle around which the intestine coils, springs from a point placed in front of the anus and attaches to the posterior end of body. A number of dissepiments are present on inner surface of the body-wall excepting the anterior region. The ventral nerve-cord is closely attached to the skin with its whole length. The intestinal convolution which consists of about 30 spirals is fixed posteriorly to the body-wall by means of the spindle-muscle. Along the dorsal side of the oesophagus there runs a polian canal bearing numerous short polian tubules on it. The anterior portion of the rectum is fixed to the body-wall by means of a number of wing-muscles. A pair of segmental organs are present. Their external apertures are situated between the 3rd and 4th longitudinal muscle-bands at a level slightly in front of the anus.

Distribution:

In Japan: Hattosi (Formosa) and Miyako (Riukiu Islands).

Foreign: Reed Batavia; Loyalty Island; Gavutu near Florida; Christmas Island; Zanzibar.

Remarks: Siphonosoma edule (SLUITER) closely resembles *Siphonosoma cumanense* (KEFERSTEIN) in internal anatomy. But there exist some differences between these two species in external characteristics. SLUITER (1886, p. 484–485) pointed out on this point that: — "Es ist namentlich der *S. edulis* dem *S. cumanensis* (KEF.) sehr ähnlich..... Der Unterschied zwischen beiden Arten wäre also hauptsächlich dass der Rüssel bei *S. edulis* viel kürzer ist als bei *S. cumanensis*, wo er noch immer 1/3 der Körperlänge beträgt, indem er bei *S. edulis* nur 1/10 der Körperlänge beträgt....."

Siphonosoma edule (SLUITER) is one of the species widely distributed in the tropical region. To the writer's knowledge, however, it has not been hitherto obtained from the adjacent seas of Japan before the present collection.

27. Siphonosoma hataii SATÔ

Siphonosoma hataii SATÔ, 1935, pp. 305-308, Pl. III, Fig. 7, Text-figs. 3-7.

Distribution: Palau Island.

28. Siphonosoma takatsukii SATÔ

Siphonosoma takatsukii SATÔ, 1935, pp. 308-310, Pl. III, Fig. 8, Text-figs. 8-10.

Distribution: Yap Island.

29. Siphonosoma formosa, n. sp.
(Pl. XX, Fig. 7; Text-figs. 14-17)

A single specimen upon which this new species was established was collected at Hattosi in Formosa on March 28th, 1936.

The specimen (Pl. XX, Fig. 7) is about 100 mm in trunk-length and is about 10 mm in thickness of trunk being measured in the middle portion of the body. The introvert is about one-fourth as long as the trunk. The body tapers posteriorly to a point. The ground colour of the skin is gray when preserved in alcohol. In both of the introvert and the posterior end of the body, the skin shows yellowish colour. On the surface of the trunk, there exist a number of longitudinal shallow grooves which correspond to the longitudinal muscle-bands lying on the inner surface of the skin. The skin is beset with numerous papillae (Text-figs. 14-16). Those found at the introvert-basis and at the posterior end of the trunk are especially tall and large (Text-fig. 16). In the middle region of the trunk the skin-papillae are very small
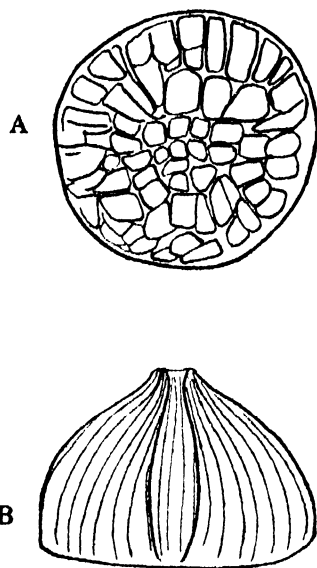
Text-fig. 14. *Siphonosoma formosa,* n. sp. Skin-papillae from the introvert-basis. A, Surface-view; B, Side-view. ×145.

and nearly flat and thus they are almost invisible to the naked eye.
The papillae found on the introvert-basis are largest of all. The measure-

A   B
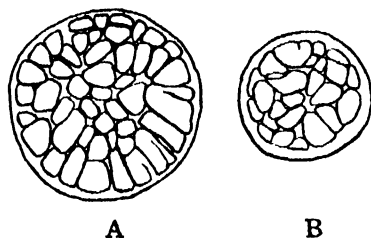
Text-fig. 15. *Siphonosoma formosa*, n. sp. Skin-papillae
from the middle region of the trunk. A, a large papilla;
B, a small papilla. (Surface-view). × 145.

B

A
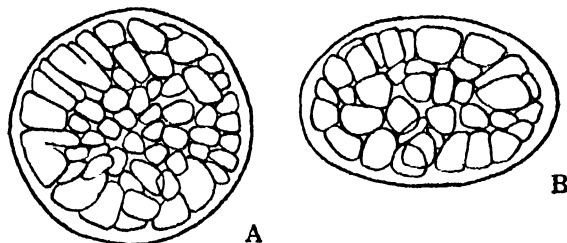
Text-fig. 16. *Siphonosoma formosa*, n. sp. Skin-papillae from
the posterior region of the trunk. A, a roundish papilla; B, a
elliptical papilla. (Surface-view). × 145.

ments of these papillae mentioned above, are indicated in the following
table.

TABLE III

Measurements of the skin-papillae.

	Height	Diameter
Skin-papillae found on the introvert-basis	0.1 - 0.2 mm	0.2 –0.4 mm
The same found in the middle of the trunk	0.02-0.05 mm	0.01-0.02 mm
The same found at the posterior end of trunk	0.05 0.1 mm	0.1 –0.3 mm

The tentacles are of filamentous and are numerous.

The longitudinal muscle layer of the body-wall is divided into 18
separate bands, very rarely anastomosed (Text-fig. 17, lm), but in the
region of the introvert they fuse together to form a continuous sheet.

Two pairs of the retractor muscles are present. The ventral pair (Text-fig. 17, vrm) are broader than the dorsal, arising from the 1st–3rd longitudinal muscle-bands, while the dorsal pair (Text-fig. 17, drm) arise from the 6th–7th of the same. The roots of these four retractor muscles are situated at the same level. A spindle-muscle (Text-fig. 17, sm) around
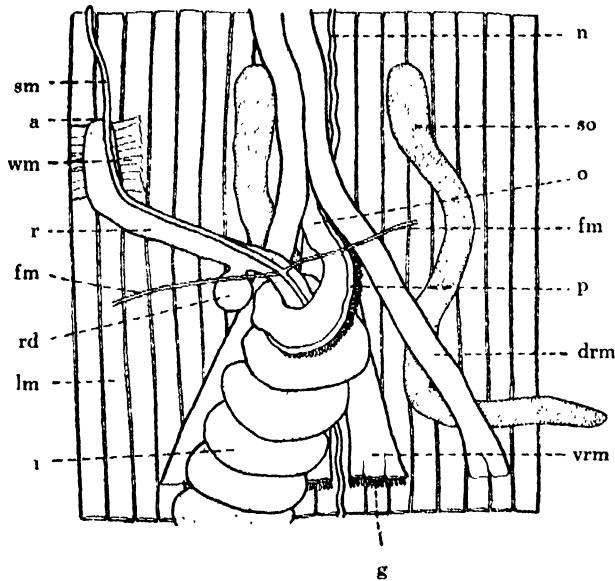
Text-fig. 17. *Siphonosoma formosa*, n. sp. Specimen dissected to show the anterior region of the trunk. a, anus; drm, dorsal retractor muscle; fm, fixing-muscle; g, gonad; i, intestinal convolution; lm, longitudinal muscle band; n, ventral nerve-cord; o, oesophagus; p, polian canal; r, rectum; rd, rectal diverticulum; sm, spindle-muscle; so, segmental organ; vrm, ventral retractor muscle. ×2.5.

which the intestine coils, springs anteriorly from a point placed in front of the anus and posteriorly it attaches to the posterior end of the body. There are two fixing-muscles (Text-fig. 17, fm) which arise from the rectum and are attached to the body-wall. The intestinal convolution (Text-fig. 17, i) which consists of about 30 spirals is fixed posteriorly to the body-wall by means of the spindle-muscle. Along the dorsal side of the oesophagus there is attached a polian canal (Text-fig. 17, p) bearing numerous short polian tubules. A comparatively large diverticulum (Text-fig. 17, rd) is found upon the rectum (Text-fig. 17, r). The anterior portion of the rectum is fixed to the body-wall by means of the wing-muscles (Text-fig. 17, wm). A number of dissepiments are present on the inner surface

of the body-wall except for the anterior region. The ventral nerve-cord (Text-fig. 17, n) is closely attached to the inner surface of the body-wall with its whole length. A pair of segmental organs (Text-fig. 17, so), each in the form of a slender sac and of a grayish yellow colour, are measured about 25 mm in length. Their external apertures are situated between the 3rd and 4th longitudinal muscle-bands at a level placed in some distance anteriorly of the anus. Of these organs, the anterior 4 mm of their length is connected to the body-wall by means of the mesentery. No eye-spot can be detected upon the cerebral ganglion. The sexual organs (Text-fig. 17, g) are represented by a pair of narrow transverse bands lying along the base of the ventral retractor muscles.

Distribution: Hattosi in Formosa.

Remarks: As the members of the genus *Siphonosoma*, there are hitherto known only three species which are nearly equally characterized as the present new species, viz. in the possession of the 18 longitudinal muscle bands and in the absence of the hooks on the introvert. They are *Siphonosoma bonhorei* (HERUBEL), *Siphonosoma carolinense* SPENGEL and *Siphonosoma joubini* (HERUBEL).

Of these three mentioned above, the first and the second species distinctly differ from this new species in having the feature of the longitudinal muscle-bands frequently anastomose. In the present new species the anastomosis of the longitudinal muscle-bands occur very rarely. The third species (*Siph. joubini*) also seems to be closely allied to the present new species, but there exist marked differences between these two in the number of tentacles as well as in the feature of the skin-papillae distributed on body-surface.

30. Siphonosoma pescadolense, n. sp.
(Pl. XX, Fig. 8; Text-figs. 18-22)

Only one specimen of this new species was collected at the beach of Makô in Hoko-tô, Formosa.

The body is about 70 mm long and is 3–5 mm thick. The introvert when fully protruded from the trunk, is about half as long as the body. The skin, when the animal is alive, is yellowish-white; however, it becomes yellowish-gray when preserved in alcohol. The body-wall is very thin being somewhat translucent. The outer surface of the body-wall is beset with numerous skin-papillae.' The skin-papillae on the introvert are very small and are regularly arranged in many rows (Text-fig. 18). They are
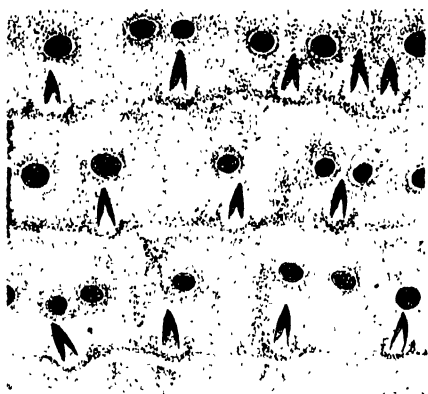
Text-fig. 18. *Siphonosoma pescadolense*, n. sp. A piece of skin from the introvert, showing the rows of papillae and spines. ×50.
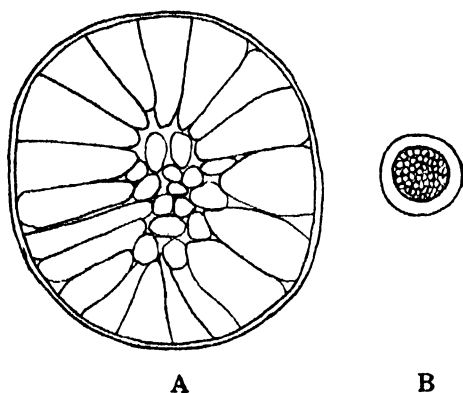
Text-fig. 20. *Siphonosoma pescadolense*, n. sp. Skin-papillae from the introvert-basis. A, a larger papilla; B, a smaller papilla. (Side-view). ×145.
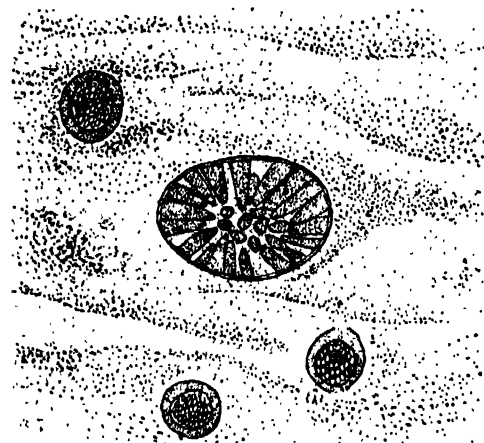
Text-fig. 19. *Siphonosoma pescadolense*, n. sp. A piece of skin from the middle region of the trunk, showing the skin-papillae. ×145.

uniform in size measuring 0.05–0.07 mm in basal diameter and are about 0.05 mm in height. In the region of the trunk, we find a number of large flat papillae mixed with small ones mentioned above (Text-fig. 19). They are somewhat elliptical in surface view, measuring 0.15–0.2 mm in major axis and 0.1–0.15 mm in the minor. Towards the introvert-basis, these skin-papillae gradually become larger, attaining 0.3–0.4 mm in major axis and 0.2–0.3 mm in the minor (Text-fig. 20).

At the posterior extremity of the trunk, the skin-papillae are not so large as those found on the introvert-basis.

At the anterior portion of the introvert, there are seen numerous spines arranged in many transverse rows (Text-fig. 21). Tentacles are filamentous and are numerous.

The longitudinal muscle layer of the body-wall is divided into separate
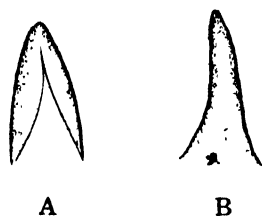
Text-fig. 21. *Siphonosoma pes-cadolense*, n. sp. Spines from the introvert. A, frontal view; B, side view. ×145.

bands. They are about 15 in number and are very rarely anastomosed. Of the four retractor muscles, the ventral pair arise from 2nd–3rd longitudinal muscle-bands in some way behind the dorsal pair. Each of the dorsal retractor muscles has its origin in the 3rd–4th longitudinal muscle-bands (Text-fig. 22). The intestine (Text-fig. 22, i) has about 12 coils, and its posterior end is attached to the body-wall by means of the spindle-muscle (Text-fig. 22, sm). The anterior portion of the intestinal convolution is fixed to the body-wall by three fixing-muscles (Text-fig. 22, fm). The segmental organs (Text-fig. 22, so) are free from the body-wall excepting the anterior extremity. The external openings of the organs are situated at nearly the same level as the anus. No diverticulum is found upon the rectum (Text-fig. 22, r).

Distribution: Makô in Hôko-tô, Formosa.

Remarks: As the members of the genus *Siphonosoma* hitherto reported,

Text-fig. 22. *Siphonosoma pescadolense*, n. sp. Specimen dissected. dr, dorsal retractor muscle; fm, fixing-muscle; i, intestine; in, introvert; lm, longitudinal muscle-band; n, ventral nerve-cord; o, oesophagus; r, rectum; sm, spindle-muscle; so, segmental organ; t, tentacular crown; v, ventral retractor muscle. ×1.5.

only four species all of which bearing the spines on the introvert. They are *Siphonosoma australe* (KEFERSTEIN), *Siphonosoma arcassonense* (CUÉNOT), *Siphonosoma parvum*

(FISCHER) and *Siphonosoma takatsukii* (SATÔ).

The present new species, however, may be easily distinguished from these four by the number of the longitudinal muscle-bands and by the features of the skin-papillae.

31. Siphonosoma koreae, n. sp.
(Pl. XXIII, Fig. 34; Text-figs. 23–26)

A single specimen upon which this new species was based was collected at Gunzan in Korea on Sept. 2nd, 1937.

The specimen (the type of this new species) is about 180 mm in length of trunk and 7–10 mm in thickness. The introvert, the half of which is withdrawn into the trunk, measures about 40 mm in length (Pl. V, Fig. 34).

The ground colour of the body-wall is grayish white when preserved in formalin. But in the region of the posterior end of the trunk, the skin shows light yellow colour. The introvert shows very beautiful deep yellow colour.

On the surface of the trunk, there exist a number of longitudinal shallow grooves which correspond to the longitudinal muscle-bands lying on the inner surface of the skin.

The skin is beset with numerous skin-papillae. Those found at the introvert-basis are crowded and arranged in a number of longitudinal rows (Text-fig. 23). They are hemispherical in form, measuring 0.4–0.6 mm both in height and diameter. Each of the skin-papillae is surrounded by a dark pigmented rim of yellow colour (Text-fig. 23). The skin-papillae found on the posterior end of the body (Text-fig. 24) are not so prominent as those found on the introvert-basis,

Text-fig. 23. *Siphonosoma koreae*, n. sp. A piece of skin from the introvert-basis, showing the papillae. ×33.
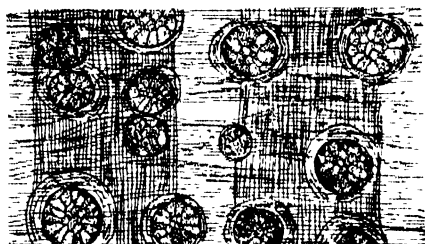
Text-fig. 24. *Siphonosoma koreae*, n. sp. A piece of skin from the posterior end of body, showing the papillae. ×27.

measuring about 0.2 mm in height and 0.3–0.4 mm in diameter of the base. In the middle region of the trunk, the skin-papillae are flat and roundish in the surface view, measuring 0.2–0.4 mm in diameter (Text-fig. 25). On the introvert, the skin-papillae are minute and arranged transversly, measuring 0.07–0.1 mm in diameter at the base (Text-fig. 26).
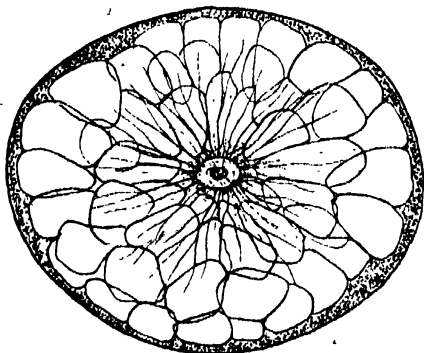
Text-fig. 25. *Siphonosoma koreae*, n. sp. A papilla from the middle region of trunk (surface view). ×145.
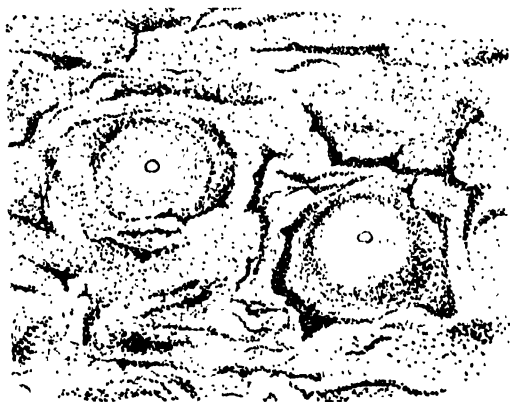
Text-fig. 26. *Siphonosoma koreae*, n. sp. A piece of skin from introvert, showing the papillae. ×145.

The longitudinal muscle layer of the body-wall is divided into 19 separate bands, but in the region of the introvert they fuse together to form a continuous sheet. Two pairs of retractor muscles are present. The roots of these four muscles are situated at nearly the same level. A stout spindle-muscle around which the intestine coils, springs from a point placed in front of the anus and is attached to the posterior end of the body. A number of dissepiments are found on the inner surface of the body-wall excepting its anterior region. The ventral nerve-cord is closely attached to the skin with its whole length. The intestinal convolution which consists of about 30 spirals is fixed posteriorly to the body-wall by means of the spindle-muscle. Along the dorsal side of the oesophagus there runs a polian canal bearing numerous short polian tubules on it. The anterior portion of the rectum is fixed to the body-wall by means of wing-muscles. A pair of segmental organs are present. They are narrow and long tubes, and are reddish brown in colour. Their external apertures are situated

between the 3rd and 4th longitudinal muscle-bands at a level slightly in front of the anus. Each of the organs is free from the body-wall except for its anterior short part. A large rectal diverticulum is found upon the digestive truct in the anterior portion of the rectum. Tentacles are long and very numerous.

Distribution : Gunzan in Korea.

Remarks : This new species is obviously like *Siphonosoma cumanense* (KEFERSTEIN) in internal anatomy, but the former may be easily distinguished from the latter by the colouration of the skin as well as the features of the skin-papillae distributed on the introvert-basis.

Genus PHYSCOSOMA SELENKA

The longitudinal muscle layer of the body-wall is separated into bands. Finger-shaped tentacles are arranged in a semicircle above the mouth. Hooks are usually present. There are two or four retractor muscles. A spindle-muscle around which the intestine coils spirally is fixed to the body-wall at both ends. One or more number of fixing-muscles are present. There are two segmental organs. The skin-papillae are remarkably large. The dorsal vessel is generally simple.

32. Physcosoma scolops (SELENKA & DE MAN)
(Pl. XX, XXIII, Figs. 9, 38, 39)

Phymosoma scolops, SELENKA & DE MAN, 1883–1884, p. 75, Pl. II, Fig. 17; Pl. X, Figs. 138–144; 1885, p. 21; SLUITER, 1890, p. 119; FISCHER, 1892, p. 86; COLLIN, 1901, p. 304; AUGENER, 1903, p. 297–371; IKEDA, 1904, p. 20; HERUBEL, 1904, p. 476–480, Text-fig. 1; 1907, p. 221.

Physcosoma scolops (SELENKA & DE MAN), SHIPLEY, 1898, p. 56; 1899, p. 470; p. 156; 1902, p. 135; 1903, p. 174; SLUITER, 1898, p. 443; 1902, p. 12; LANCHESTER, 1905, p. 28, p. 30 and p. 36; FISCHER, 1913, p. 98; 1914, pp. 1–28; 1914, pp. 59–84, Pl. XI, Figs. 6 8; 1922, p. 15; 1926, p. 108; IKEDA, 1924. p. 31; TEN BROEKE, 1925, p. 6; SATÔ, 1930, pp. 11–15. Pl. II, Figs. 9–10, Text-fig. 3; 1935, p. 313, Pl. IV, Fig. 14; 1937, pp 150–151, Pl. II, Fig. 7; STIASNY, 1930, p. 209.

Many specimens were collected at various localities as shown in the Table IV.

The body-wall is thin, yellowish-brown in colour and is covered with numerous large skin-papillae of deep brown colour. Each skin-papilla is cylindrical in form with a conically pointed tip and is thickly beset with numerous polygonal chitinous plates. These skin-papillae found at the

TABLE IV

The localities of Physcosoma scolops distributed in
Formosa and Korea.

Localities	Date	Collector
Formosa		
Daizyubô	March 20, 1936	H. SATÔ
Korea		
Uturyô-tô	?	H. SATÔ
Saisyû-tô	?	H. KURIHAHA
Taisei (Saisyu-tô)	July 18, 1936	S. OKUDA
Kinnei (Saisyu-tô)	July 24, 1936	S. OKUDA
Zinsen	?	T. KAMITA
Kaisyû	Aug. 31, 1937	H. SATÔ
Genzan	Aug. 20, 1937	H. SATÔ
Zyôsin	Aug. 22, 1937	H. SATÔ

introvert-basis and at the posterior end of the body are extremely tall, measuring 0.2–0.3 mm high and 0.1–0.2 mm wide at the base; while those distributed in the middle region of the trunk are flattened, measuring about 0.1 mm in height and 0.1–0.15 mm in width at the base.

On the dorsal surface of the introvert there are several pigmented bands of dark brown colour. About 15–20 rows of hooks are present behind the tentacular crown. Each hook is about 0.04–0.07 mm both in height and width of the base, and is deep brown in colour. It has a strongly curved apical tooth. In the side view of the hook, we notice a canal-like transparent streak. A short transverse bar, having several minute warts close to its posterior end, is present at the base of the hook above mentioned. Between every two rows of the hooks there exist small perforated papillae of about 0.01 mm high and wide. The tentacles are filamentous and are about 20 in number. They are arranged in a semicircle above the mouth.

The longitudinal muscle layer of the body-wall is divided into many separate bands, several of which being anastomosed. In the region of introvert, these bands are entirely fused each other into to form a continuous sheet. The circular muscle layer is continuous. Of the four retractor muscles, the ventral pair are larger than the dorsal and spring from the 2nd–7th longitudinal muscle-bands at the level of one-third of the body-length being measured from the posterior end of the body;

while the dorsal pair arise far anteriorly from the 5th–8th longitudinal muscle-bands. A simple stout fixing-muscle which arises in front of the anus is fixed to the posterior end of the body at its extremity. A fixing-muscle springs from the body-wall on the left side of the nerve-cord and attaches to the first whorl of the intestinal coil. Wing-muscles are well developed. The intestinal convolution consists of about 15 spirals which coils around the spindle-muscle. No rectal diverticulum is present upon the rectum. The anus is situated almost at the same level with the external apertures of the segmental organs. A polian canal, which does not carry any tubules upon it, is found to run along the dorsal side of the oesophagus. The segmental organ consists of two long tubes of a reddish-brown colour, and their anterior half is fixed to the body-wall by means of the mesenteries. A pair of eye-spots are found on the cerebral ganglion.

Distribution: •

In Japan: · This cosmopolitan species is obtained at many localities distributed in the Japanese waters. According to IKEDA (1904 and 1924), the present species was collected from the Hokkaidô in the north and from Riukiu Islands in the south. The species has been also reported by the writer (1930, 1935 and 1937) the specimen being obtained from the following localities: Mutsu Bay (Aomori prefecture), Tobi-sima (Yamagata prefecture), Nezugaseki (Yamagata prefecture) and Palau (the West Caroline Islands).

Foreign: Philippine, Singapore, Java, Batavia, the Red Sea, Zanzibar, Funafuti, Loyalty Islands, West Africa, Indian Ocean, the Maldive Islands, Laccadive Islands, New Zealand, Tasmania, British East Africa, the Gulf of Suez, Port Natal, New Britain, Germany, France and Koseir.

33. Physcosoma japonicum (GRUBE)
(Pl. XX, Fig. 12; Pl. XXIII, Fig. 41; Text-figs. 27-29)

Phascolosoma japonicum, GRUBE, 1877, Vier und fünfzigster Jahresbericht der Schles. Gesellschaft für faterländischer Cultur, Breslau, p. 73.

Phymosoma japonicum (GRUBE), E. SELENKA, 1883, p. 220-222; 1883-1884, p. 76, Pl. II, Figs. 18-19; Pl. X, Figs. 145-146; 1885, p. 21; FISCHER, 1895, p. 12; IKEDA, 1904, p. 22.

Physcosoma japonicum (GRUBE), OSTROUMOV, 1909, p. 319-324; FISCHER, 1914, pp. 1-28; 1928, p. 13; CHAMBERLIN, 1920, p. 5; SATÔ, 1930, pp. 9-11, Pl. I, Fig. 5, Text-fig. 2; 1937, pp. 149-150, Pl. II, Figs. 5-6.

In the present collection there are five specimens obtained from

Daihanratu in Formosa and two collected at Seisin in Korea. They were all obtained under the stones lying between the tide-marks.

The specimens are all small in size. The largest one which was secured in Korea, the body measures about 40 mm in length and 3–5 mm in diameter measured at the widest part of the trunk. The introvert is much narrower and slightly shorter than the trunk.
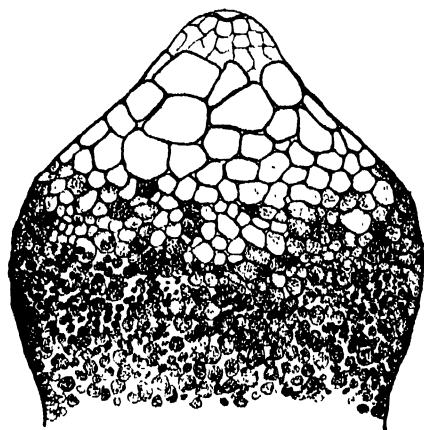
Text-fig. 27. *Physcosoma japonicum* (GRUBE). A skin-papilla from the introvert-basis. (Side-view). ×290.
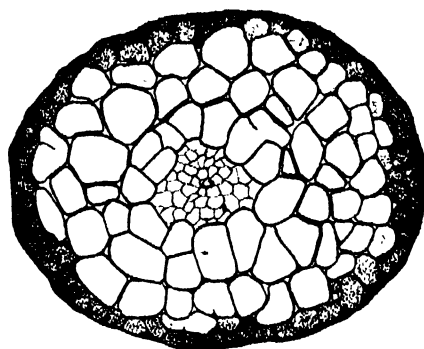
Text-fig. 28. *Physcosoma japonicum* (GRUBE). A skin-papilla from the middle region of the trunk. (Surface view). ×290.

The skin of the body-wall is yellowish gray, and is covered with numerous skin-papillae of brown colour. The skin-papillae (Text-figs. 27–29) are cone-shaped and each is provided with a small aperture in the centre. Each skin-papilla is thickly covered with numerous small polygonal chitinous plates. At the introvert-basis and at the posterior end of the body these skin-papillae become tall; while in the middle region of the trunk they
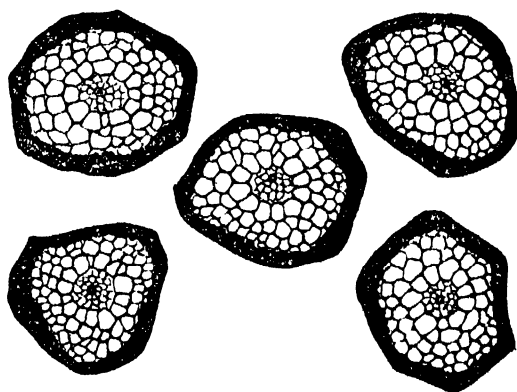
Text-fig. 29. *Physcosoma japonicum* (GRUBE). Skin-papillae from the posterior of region of the trunk. (Surface view). ×97.

are low and small having such dimensions as shown in the following table.

<div align="center">

TABLE   V

Measurements of the skin-papillae.

</div>

	Height	Width
Papillae from introvert	0.05 -0.07 mm	0.03-0.05 mm
Papillae from introvert-basis	0.2 -0.27 mm	0.2 -0.25 mm
Papillae from middle region of trunk	0.1 -0.15 mm	0.15-0.18 mm
Papillae from posterior end of trunk	0.18-0.2 mm	0.15-0.2 mm

At the anterior end of the introvert, just behind the tentacular crown, there are about 30 circular rows of hooks. The hooks are about 0.07 mm both in height and width. Tentacles are finger-shaped and are about 20 in number. They are arranged in a semicircle above the mouth.

The longitudinal muscle layer of the body-wall is divided into 20–25 separate bands. They are anastomosed here and there with one another, and in the region of the introvert they are fused to form a continuous sheet. Of the four retractor muscles, the ventral pair are larger than the dorsal and spring from the 3rd–8th longitudinal muscle-bands; while the dorsal pair arise far anteriorly and from 5th–6th longitudinal muscle-bands. A simple stout spindle-muscle which arises in front of the anus is fixed to the posterior end of the body at its extremity. The intestinal convolution consists of about 10 spirals. A polian canal bearing no tubules upon it, is found running along the dorsal side of the oesophagus. The segmental organs consists of two sacs of a yellowish-brown colour. Their external apertures lie almost at the same level with the anus, and the anterior half of the organ is connected with the body-wall by means of mesentery. A pair of eye-spots are visible on the cerebral ganglion.

Distribution :

In Japan : Hokkaidô, Northeast Honsyû, Misaki, Enosima, Korea and Formosa.

Foreign : Port Jackson, Port Natal, De Castries Bay, Sidney, New Britania and British Columbia.

Remarks : In the specimens from Formosa, the feature of the transparent streak of the hook is somewhat different from the figures given by SELENKA of the same species (1883–1884, Taf. X, Fig. 145). Of this species, however, the shape of the transparent streak of the hook seems

to be rather variable and is not able consider it as a definite specific character. I am therefore inclined to identify the specimens above mentioned with *Physcosoma japonicum.*

34. Physcosoma granulatum (Leuckart)
(Pl. XXIII, Fig. 40)

Phascolosoma granulatum, Leuckart, 1828, p. 22, Fig. 5; Keferstein, 1862, p. 35;
    1865, pp. 426–427.
Phymosoma granulatum (Leuckart), Selenka & De Man, 1883–1884, pp. 79–82, Taf.
    X, Figs. 147–151; Taf. XI, Figs. 152-155; Collin, 1892, p. 181; Fischer,
    1895, pp. 9 -10; Augener, 1903, pp. 297–371.
Physcosoma granulatum (Leuckart), Sluiter, 1900, p. 13: 1912, p. 19; Southern,
    1913, p. 1; 1913, pp. 1–46; Fischer, 1914, pp. 1–28; pp. 59–84; 1922, p.
    11; Cuénot, 1922, pp. 16-17; 1927, p. 249; Satô, 1935, pp. 312-313, Pl. IV,
    Fig. 13.

Two specimens of this species were obtained at the shore of Zinsen in Korea on Sept. 7th, 1937. They are rather small in size, measuring 20–30 mm in trunk-length.

This species, on the one hand, closely resembles *Physcosoma scolops* in the form of polygonal chitinous plates on the skin-papillae, but on the other hand it is quite similar to *Physcosoma japonicum* in the form of hooks. I consider, therefore, that the present species might be an intermediate form between these two species.

Distribution :

In Japan : Palau, Yap and Korea.

Foreign : Zanzibar, Nizza, Graciosa, Kapverad Island, Irland, Mediterranean Sea and France.

35. Physcosoma yezoense Ikeda

Physcosoma yezoense Ikeda, 1924, pp. 32–34, Figs. 3-6.

Distribution : Osyoro (Hokkaidô).

36. Physcosoma glaucum Satô

Physcosoma glaucum Satô, 1930, pp. 15–17, Pl. I, Fig. 6, Pl. II, Figs. 7–8, Text-fig. 4.

Distribution : Mutsu Bay.

37. Physcosoma kurilense Satô

Physcosoma kurilense Satô, 1937, pp. 117–120, Figs. 1–4.

Distribution: Shumshir Island.

Remarks: From the zoogeographical view-point, the present species brings us great interest in that it is a unique species obtained from the Kurile Islands, and moreover in that its habitat represents the northern limit of the distribution of Sipunculoidea in Japan.

38.   Physcosoma nigrescens (KEFERSTEIN)
(Pl. XX, Fig. 13; Text-figs. 30–32)

Phascolosoma nigrescens KEFERSTEIN, 1865, p. 424, Taf. XXVI, Fig. 2; Taf. XXXII,
Figs. 14-15; BAIRD, 1868, p. 94.

Phymosoma nigrescens (KEFERSTEIN), SELENKA, 1883–1884, pp 72–74; SLUITER, 1890, p.
119; FISCHER, 1895, pp. 10-12; COLLIN, 1901, p. 305; AUGENER, 1903, pp.
297–371.

Physcosoma nigrescens (KEFERSTEIN), SHIPLEY, 1898, p. 470; 1899, p. 156; 1902, p. 134;
SLUITER, 1902, p. 11; LANCHESTER, 1905, p. 30; 1905, p. 36; FISCHER, 1913,
p. 98; 1914, pp. 59–84, pp. 1-28; 1919, p. 280; 1921, p. 4; 1921, p. 414;
1922, p. 14; 1926, pp. 201–202; 1926, p. 108; SATÔ, 1935, p. 311, Pl. IV,
Fig. 10.

Several specimens of this species were taken from Hôko-tô in Formosa. They were found inside of a dead coral placed in such place as to be exposed in the air when it is low tide.

The trunk measures about 25 mm in length, and about 5 mm in thickness of body. The introvert which is much narrower than the trunk is about half as long as the trunk-length when it is contracted.

The skin is opaque and is yellowish brown in colour. Numerous skin-papillae are found on the surface of the body. Those found on the posterior end of body and in the region of the introvert-basis, are extremely prominent; while those found in the middle region of the trunk, are small and low (Text-fig. 30). The dimensions of these skin-papillae are shown in the Table VI.

Text-fig. 30.   *Physcosoma nigrescens* (KEFERSTEIN).   A skin-papilla from the middle region of trunk. (Surface-view). ×290.

About 70 circular rows of hooks are present behind the tentacles on the introvert. Each hook (Text-fig. 31) is small in size, measuring only about 0.05 mm in height and 0.06 mm in breadth of the base.

The longitudinal muscle layer of the body-wall is divided into 22–30 separate bands. They are frequently anastomosed. In the region of the

Table   VI

Measurements of the skin-papillae.

Skin-papillae	Height	Width
from introvert	0.06–0.08 mm	0.04–0.06 mm
from introvert-basis	0.2 –0.25 mm	0.15–0.2 mm
from middle region of trunk	0.05–0.1 mm	0.06–0.1 mm
from posterior end of trunk	0.12–0.15 mm	0.1 –0.15 mm
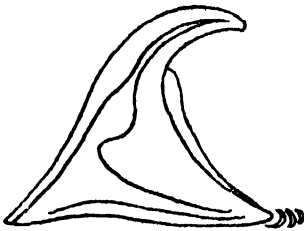
Text-fig. 31. *Physcosoma nigrescens* (KEFERSTEIN). A hook from the introvert. (Side-view). ×580.

introvert, however, they fuse together to form a continuous sheet. Two pairs of the retractor muscles are present. The ventral pair (Text-fig. 32, vr) are broader than the dorsal and arise from the middle region of the trunk. The dorsal pair (Text-fig. 32, dr) are narrower than the ventral, and arise at a level placed more anteriorly than the ventral pair. A spindle-muscle (Text-fig. 32, sm) arises from the body-wall in front of the anus, and
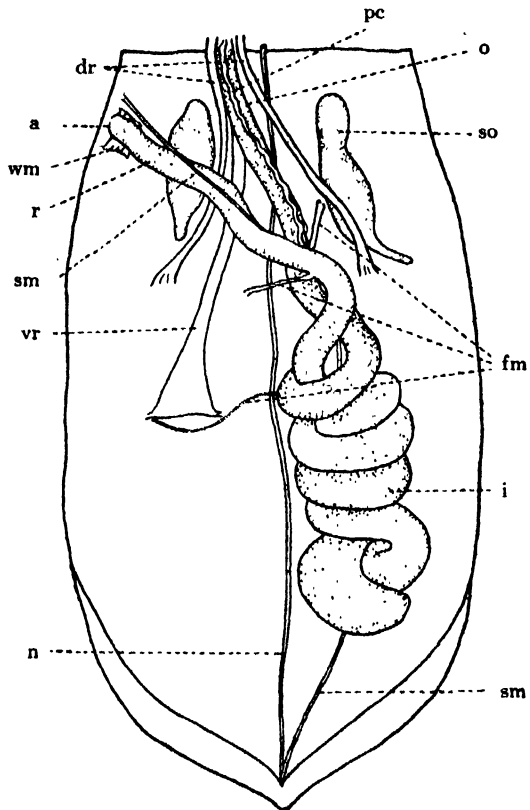
Text-fig. 32. *Physcosoma nigrescens* (KEFERSTEIN). Specimen dissected.   a, anus; dr, dorsal retractor muscle; fm, fixing-muscles; i, intestinal convolution; n, ventral nerve-cord; o, oesophagus; pc, polian canal; r, rectum; sm, spindle-muscle; so, segmental organ; vr, ventral retractor muscle; wm, wing-muscle. ×4.

is fixed to the posterior end of the trunk. Of three fixing-muscles, the
two arise from the body-wall on the right side of the nerve-cord ; while
the remaining arises from the body-wall near the left segmental organ,
and inserts to the rectum (Text-fig. 32, fm). The intestinal convolution
(Text-fig. 32, i) consists of about 6 spirals coiled around the spindle-muscle.
A simple polian canal (Text-fig. 32, pc) is found only on the dorsal side
of the oesophagus (Text-fig. 32, o). No diverticulum is found upon the
rectum. The anus (Text-fig. 32, a) is situated almost at the same level
with the external apertures of the segmental organs. The segmental
organs (Text-fig. 32, so) are short tubes of a yellowish brown colour, and
their anterior half is fixed to the body-wall by means of the mesenteries.

   Distribution :

   In Japan :   Palau, Yap and Formosa.

   Foreign :   This widely distributed species has been reported from
the following localities: Fidji Island ; Philippine Archipelagoes ; Mauri-
tius ; Red Sea ; Biliton ; Batavia ; West Africa ; Madagaskar ; New Bri-
tania ; Funafuti ; Maldive and Laccadive Islands ; Port Natal ; Kapverdes
Island ; Goldkuste ; Costa Rica, Mozambique ; Annobon Island, Cap Jau-
bert, Port Grande, Sharks Bay, Gazelle-Halbinsel ; Zanzibar ; East coast
of South America ; St. Barthelemy ; Honolulu ; Ceylon.

   Remarks :   The present specimens from Formosa seems to be identified
with *Physcosoma nigrescens* which was first described by KEFERSTEIN in
1865 dealing with the specimens from " Viti-Inseln ".

<div align="center">TABLE VII</div>

Specimens from Formosa	KEFERSTEIN's original description	SELENKA's monograph
Height of hook 0.05 mm	Height of hook 0.084 mm	Height of hook 0.09 mm
Breadth of hook 0.06 mm	Breadth of hook 0.084 mm	Breadth of hook 0.1 mm
A simple polian canal is found only on the dorsal side of the oesophagus.		" Contractier Schlauch mit vielen kleinen kurzen Blind-säcken "
Of the two fixing-muscles, the one arises from the body-wall on the left side of the nerve-cord in close approximation and inserts to the rectum ; while the remaining one arises from the body-wall near the right segmental organ, and inserts to the rectum.		" An den ersten Windung ein Befestiger, welcher sich neben den Bauchnerven-strange auf der Höhe der vorderen Retractor-wurzeln inseriert ".

In dissecting the specimens, however, several differences existing be-
tween the present specimens and descriptions given by KEFERSTEIN (1865)
and SELENKA (1883–1884), were revealed as shown in the Table VII.

39. Physcosoma pacificum (KEFERSTEIN)

Phascolosoma pacificum KEFERSTEIN, 1867, pp. 49–50, Taf. VII, Figs. 1–2; BAIRD, 1868,
    p. 96.
Phymosoma pacificum (KEFERSTEIN), SELENKA et DE MAN, 1883–1884, pp. 63–65, Taf. I,
    Fig. 6; Taf. VII, Figs. 111–112; SLUITER, 1890, p. 119; FISCHER, 1895, p.
    12; AUGENER, 1903, pp. 297–371; IKEDA, 1904, pp. 25–26; 1905, p. 169.
Physcosoma pacificum (KEFERSTEIN), SHIPLEY, 1898, p. 470, Pl. 37, Fig. 6; 1899, p. 156;
    1902, p. 134; SLUITER, 1902, p. 11; FISCHER, 1914, pp. 1–28; 1926, p. 108;
    SATÔ, 1935, pp. 310–311, Pl. III, Fig. 9.

A single specimen of this species was taken from Daihanratu in For-
mosa. The animal was found burrowing in some fissures of coral rocks
laid between the tide-marks.

The total length of the animal is about 100 mm when the introvert
is fully stretched. The introvert is a little longer than the trunk.

The body-wall is grayish-brown, and the introvert bears on its dorsal
side a number of irregular pigmented bands. The skin is thick, hard,
perfectly opaque, and with very rough surface due to the presence of
tall skin-papillae closely set. The skin-papillae found on the region of
the introvert-basis and on the posterior end of the trunk, are larger and
more crowded than those distributed on the rest of trunk. They measure
0.2–0.3 mm in height.

At the anterior end of the introvert, and close to the tentacular crown,
there exist about 80 rings of hooks. Each of the hooks is about 0.1 mm
high, and is provided with a sharp and strongly curved apical tooth
together with a small blunt accessory tooth. Tentacles are about 35 in
number, and are arranged in a semicircle above the mouth.

The longitudinal muscle layer of the body-wall is divided into about
30 narrow bands. They anastomose frequently. Of the four retractor
muscles, the ventral pair arise from the body-wall at a level in the middle
of the trunk-length. The dorsal pair are narrower than the ventral, and
arise from the body-wall more anteriorly. The intestinal convolution
consists of about 12 spirals. A spindle-muscle arises from the body-wall
at a point close to the anus, and is fixed to the posterior end of the
trunk. Only one fixing-muscle is present. Each of the segmental organs
is very long, reaching nearly the posterior end of the body, and is

accompanied by a mesentery attached along its whole length.

Distribution :

In Japan : Yap and Formosa.

Foreign : The distribution of this species extends from the Red Sea to Pacific through the Indian Ocean. It has been hitherto reported from the following localities : the Australian Archipelagoes ; Marquesas ; Upolu ; Kingsmiles Inseln: Amboina ; Mauritius ; Viti Inseln ; Neu Guinea ; Banda-Neira ; Makassar ; Ambon ; Loyalty Islands ; Funafuti ; Rotuma ; Maldive Islands ; Laccadive Islands.

40. Physcosoma varians (KEFERSTEIN)
(Pl. XX, Fig. 11; Text-figs. 33-35)

Phascolosoma varians, KEFERSTEIN, 1865, pp. 199-200; 1865, pp. 424-426, Taf. XXXII,
   Fig. 22; 1867, pp. 48-49.
Phascolosoma puntarenae, KEFERSTEIN, 1862, p. 40, Taf. III, Figs. 1, 6, 12.
Phascolosoma perlucens, BAIRD, 1868, pp. 90-91, Pl. X, Figs. 2, 2 a.
Phymosoma varians (KEFERSTEIN), SELENKA et DE MAN, 1883 1884, pp. 69-71, Taf. IX,
   Figs. 124-127; SHIPLEY, 1890, pp. 3-29, Pl. I-IV, Figs. 1-32; AUGENER,
   1903, pp. 297-371.
Physcosoma varians (KEFERSTEIN), SHIPLEY, 1898, pp. 468-473; 1899, p. 531; GEROULD,
   1913, pp. 419-420; FISCHER, 1922, pp. 1-39; TEN BROEKE, 1925, p. 5.

Two specimens of this species were taken from Karenkô in Formosa on March 14th, 1936. They were discovered by breaking down the coral rock with a hammer.

Of these two, the one (Pl. XX, Fig. 11) which is larger than the other, measures about 60 mm in total length and is about 7 mm in breadth at the widest part of the trunk. The remaining smaller one measures about 40 mm and 5 mm in total length and diameter respectively. The introvert, which is much slender than the trunk, is nearly equally long as the trunk.

The body-wall is dirty yellowish-gray, and is covered with numerous skin-papillae of brown colour. Those found on the introvert-basis and on the posterior end of the trunk, are much taller than those found on the remaining part of the trunk. The skin-papillae are cone-shaped in the side view, being about 0.25 mm high. In the surface view, the skin-papillae show somewhat irregular ellipse in outline measuring 0.2-0.3 mm in major axis and 0.15-0.25 mm in the minor. The skin-papillae found in the middle region of the trunk are very low, measuring only about 0.1 mm in height, but the diameter of the base is almost same as that found on the other regions of the trunk. Each of the skin-papillae is covered with numerous small chitinous plates (Text-fig. 33).
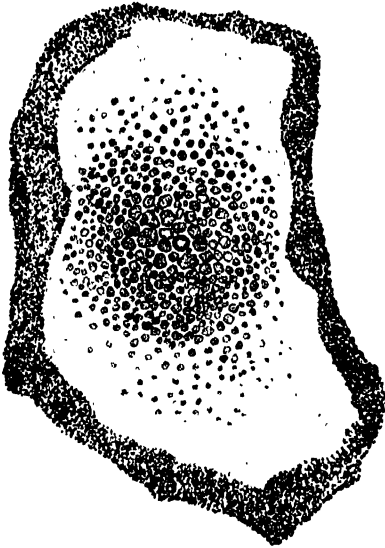
Text-fig. 33. *Physcosoma varians* (KEFER-STEIN). A skin-papilla from the middle region of trunk. (Surface view). ×435.
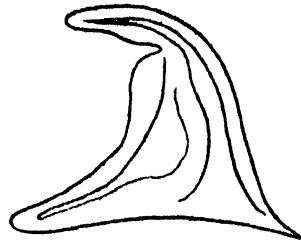
Text-fig. 34. *Physcosoma varians* (KEFERSTEIN). A hook from the introvert. (Side-view). ×435.

Near the anterior end of the introvert and close to the tentacular crown, there are found about 30 rings of hooks. Behind these rings of hooks it follows a zone in which we find a number of hooks and skin-papillae scattered and mixed. Then comes another zone of rings of hooks. In this zone, the number of the hook-rings are about 30. Each of these hooks is about 0.07 mm high and about 0.09 mm broad at the base (Text-fig. 34). It has a strongly curved apical tooth and is accompanied by a bluntly pointed accessory tooth placed in the middle of its concaved edge. Inside of the hook runs a narrow canal-like transparent streak curving gently along the convex edge. Between each two rows of the hooks above mentioned, there are a number of small perforated papillae arranged in a ring. They are about 0.018 mm both in height and width. The tentacles are about 20 in number.

The longitudinal muscle layer of the trunk is divided into many separated bands, several of which being anastomosed. They are 18–20 in number in the middle of the trunk. In the region of the introvert these bands are entirely fused into a continuous sheet (Text-fig. 35). The circular muscle layer is continuous.

Of the four retractor muscles, the ventral pair (Text-fig. 35, vr) are larger than the dorsal and spring from the 2nd–8th longitudinal muscle-bands in the middle region of the trunk, while the dorsal pair (Text-fig. 35, dr) arise far anteriorly and from the 5th–6th longitudinal muscle-bands. A stout spindle-muscle (Text-fig. 35, sm) which arises in front of the anus

is fixed to the posterior end of the body on its extremity. One fixing-muscle arises from the first longitudinal muscle band on the left side of the trunk, and is attached to the first whirl of the intestinal convolution. A pair of wing-muscle (Text-fig. 35, wm) are present on the lateral sides of the rectum near the anus. The intestinal convolution (Text-fig. 35, i) consists of about 10 spirals and its posterior end is fixed to the body-wall by means of the spindle-muscle (Text-fig. 35, sm). No diverticulum is found upon the rectum (Text-fig. 35, r). The anus (Text-fig. 35, a) is situated slightly behind the external aperture of the segmental organ. The segmental organ (Text-fig. 35, so) consists of two sacs of a brownish-gray colour. Their external aperture lie between the 2nd and the 3rd longitudinal muscle-bands. The anterior half

Text-fig. 35. *Physcosoma varians* (KEFERSTEIN). Specimen dissected. a, anus; dr, dorsal retractor muscle; g, gonad; i, intestinal convolution; in, introvert; lm, longitudinal muscle-band; n, ventral nerve-cord; o, oesophagus; r, rectum; sm, spindle-muscle; sp, skin-papilla; so, segmental organ; vr, ventral retractor muscle; wm, wing-muscles. ×2.5.

of each organ is fixed to the body-wall by mesentery. A pair of eye-spots are seen on the cerebral ganglion.

Distribution:

In Japan: Karenkô in Formosa.

Foreign: St. Thomus; Vicques; St. Croix; St. Jan. Barbados; Antillen; Florida; Bahamas; Bermudas; Ascension Island; Rotuma;

Funafuti; Key West; Dry Tortugas.

Remarks: This species was first reported by DAN. SOLANDER (1786) from the Islands of Grenades, but afterwards it was described scientifically. by W. KEFERSTEIN (1862, 1865).

From the Japanese waters, this species was obtained for the first time by the present collection.

Comparing the specimens taken from Formosa with the descriptions given by other authors, we notice some differences in characteristics among them as shown in the following table.

TABLE VIII

	Specimen described by KEFERSTEIN (1865)	Specimen treated by SHIPLEY (1890)	Specimen from Formosa
Number of tentacles	20-28	about 18	20
Number of longitudinal muscles	etwa 30	22	18-20 in the middle of trunk
Number of hook-rows	12-90	20 in the 1st region and 40-60 in the 2nd region	about 30 in the 1st region and about 30 in the 2nd region

Of this genus, however, the number of tentacles, the number of longitudinal muscle-bands and the number of hook-rows are extremely variable in each individual. Thus, I am inclined to identify this form with that species.

41. Physcosoma antillarum (GRUBE & OERSTED)

Phascolosoma antillarum GRUBE & OERSTED, 1858, Annulata Oerstdiana in Vikenskabelige Meddelelser fra den naturhist. Forening i Kjöbenhaven, pp. 117-118; DIESING, 1859, Revision der Rhyngodeen in Sitzungsber. math. naturw. Classe der kais. Akad. in Wien, p. 762; KEFERSTEIN, 1862, p. 40, Taf. III, Fig. 2 und 11; 1865, p. 435, Taf. XXXI, Fig. 11; Taf. XXXIII, Fig. 37.

Phascolosoma fuscum KEFERSTEIN, 1862, p. 67.

Phascolosoma nigriceps BAIRD, 1868, p. 90, Pl. XI, Fig. 1.

Phymosoma antillarum (GRUBE & OERSTED), SELENKA & DE MAN, 1883-1884, pp. 57-58, Taf. VII, Figs. 93-96; FISCHER, 1895, p. 12; AUGENER, 1903, pp. 297-371; IKEDA, 1904, pp. 24-25.

Physcosoma antillarum (GRUBE & OERSTED), FISCHER, 1922, GEROULD, 1913, pp. 420-421.

Distribution:

In Japan: Koniya in Amami-Ôsima; Naha, Itoman and Tinensaki in Riukiu Islands.

Foreign: St. Croix ; St. Thomas ; Surinam ; Jamaica ; Barbados ; Chili ; Puntarenas ; Puerto Cabello ; Key West ; Florida ; Muriel ; Cuba ; Columbia ; Sabanilla ; Venezuela ; Brazil.

42. Physcosoma pelma (SELENKA & DE MAN)

Phymosoma pelma SELENKA & DE MAN, 1883–1884, p. 60, Taf. I, Fig. 4, Taf. VII, Fig. 102; SLUITER, 1886, p. 504; 1890, p. 118; AUGENER, 1903, pp. 297–371.
Physcosoma pelma (SELENKA & DE MAN), SHIPLEY, 1902, p. 134; SLUITER, 1902, p. 12; FISCHER, 1922, p. 15; SATÔ, 1935, pp. 311–312, Pl. IV, Fig. 11.

Distribution :
    In Japan : Palau Island.
    Foreign : Philippine ; Java ; Amboina ; Mauritius ; Laccadive Island ; Hawaii.

43. Physcosoma nahaense (IKEDA)

Phymosoma nahaense IKEDA, 1904, pp. 29–31, Figs. 8, 59–62.
Distribution : Naha in Riukiu Island.

44. Physcosoma albolineatum (BAIRD)
(Pls. XX, XXIII, Figs. 10, 42)

Phascolosoma albolineatum BAIRD, 1868, pp. 91–92.
Phymosoma albolineatum (BAIRD), SELENKA & DE MAN, 1883–1884, pp. 71–72, Pl. IX, Figs. 128–129; AUGENER, 1903, pp. 297–371.
Physcosoma albolineatum (BAIRD), FISCHER, 1913, p. 99; 1914, pp. 1–28; 1922, p. 9; IKEDA, 1924, p. 32; SATÔ, 1935, p. 312, Pl. IV, Fig. 12.

A great number of specimens of this species were obtained by myself from the various localities in Formosa, Riukiu Islands and Korea. Of these specimens, the larger one measures about 50 mm in trunk-length being about 6 mm broad in the widest part. The introvert is very narrow, and is about the half of the trunk length. The body-wall is very thin and is somewhat translucent. In fresh state, the skin shows a beautiful yellowish vermilion colour, but when preserved in alcohol, it is tinged with light yellowish gray. On the dorsal surface of the introvert, there are usually found a number of pigmented bands of dark brown colour.

About 30 circular rows of hooks are present behind the tentacular crown on the introvert. Each of these hooks is about 0.07 mm in height and 0.09 mm in width at the base. It has a strongly curved apical tooth

making a right angle at the middle of the hook. In side-view of the hook, we notice a canal-like transparent streak. A short transverse bar having several minute warts close to its posterior end, is present at the base of the hook. Between every two rows of these hooks there exist a number of small perforated papillae of about 0.01 mm height and breadth also arranged in circular rows. The tentacles are filamentous and are arranged in a horse-shoe-shaped row above the mouth. The surface of the skin appears nearly smooth to the naked eye except for the introvert-basis and the posterior extremity of the trunk, but there may be detected numerous small skin-papillae when observed under high magnification. The skin-papillae placed in the region of the introvert-basis and of the posterior extremity are large and show dark brown colour.

The longitudinal muscle layer of the body-wall is divided into many separate bands. They are 20–30 in number and are very frequently anastomosed. In the region of the introvert, these muscle-bands are entirely fused forming a continuous sheet. The circular muscle layer is continuous. Two pairs of slender retractor muscles are present. The ventral pair of the muscles arise in the middle region of the trunk; while the dorsal pair which are narrower than the ventral arise at a level placed more anteriorly than the ventral. A spindle-muscle arises from the body-wall in front of the anus, and is fixed to the posterior end of the trunk. The intestinal convolution consists of about 10–15 spirals coiled around the spindle-muscle. The anus is situated almost at the same level as the external apertures of the segmental organs. The segmental organs are of long tubes and their anterior half is fixed to the body-wall by means of the mesenteries. Two eye-spots are found on the cerebral ganglion.

Distribution :

In Japan : Suô, Daihanratu, Daizyubê, Kotôsyo, Hattosi, Karenkô and Sinkô (in Formosa); Miyako and Naha (in Riukiu Islands); Wandô and Saisyû-tô (in Korea); Palau and Yap (in Caroline Islands).

Foreign : Philippine, Java and Amboina.

Remarks : This tropical species widely distributed in the southern part of Japanese waters, seems to be the commonest sipunculid in Formosa being obtained in the present collection at many localities mentioned above.

The animals are found in dead coral or under stones exposed to the air when it is low tide.

45. **Physcosoma onomichianum** (IKEDA)
(Pls. XX, XIII, Figs. 14, 43)

Phymosoma onomichianum, IKEDA, 1904, pp. 26-28, Pl. I, Fig. 7, Pl. III, Figs. 56-58.
Physcosoma onomichianum (IKEDA), SATÔ, 1934, p. 247.

The writer has collected many specimens of this species from Formosa
and Korea. Of these specimens, the majority were taken from Korea
and the remaining one only was secured in Formosa.

In the largest specimen which was collected in Korea, the trunk
measures about 50 mm in length and about 7 mm in thickness; while in
the smallest specimen which was obtained in Formosa the trunk measures
about 20 mm in length and about 4 mm in thickness at the widest part.

The body-wall is brownish-yellow in ground colour and is covered
with numerous large skin-papillae of dark brown colour. The skin-papillae
found in the middle region of the trunk, are slightly elevated being about
0.05 mm high and 0.15-0.25 mm in basal diameter, and each consists of
polygonal chitinous plates of deep brown colour. The non-papillated parts
of the body-surface is covered with sparsely scattered minute chitinous
plates which seem to be of the same character as those found on the
skin-papillae. On the introvert-basis as well as in the posterior region
of body, the skin-papillae are conspicuously tall, taking the form of a
cone with an obtuse apex. Each of them is consisted of thick chitinous
plates closely set in a manner like pavement. On the introvert, the
skin-papillae are also cone-shaped, but they are markedly smaller than
those found on the introvert-basis. Neither hook nor spine is present
on the introvert. The tentacles are filamentous and are very numerous.

The longitudinal muscle layer of the body-wall is divided into separated
bundles very frequently anastomosed. In the middle region of the trunk
they are about 15 in number. The retractor muscles occur in a single
pair. They are attached to the body-wall at a point placed in the pos-
terior one-third of the trunk-length. The intestinal convolution consists
of about 10-50 spirals, twisted around the spindle-muscle, the posterior
end of which being fixed to the body-wall. The anus is situated near
the anterior end of the trunk, at the same level as the external apertures
of the segmental organs. The segmental organs are long, each being
nearly half as long as the trunk; and being attached to the body-wall
with its whole length by a thin mesentery. Numerous polian tubules
are present upon the polian canal which runs along the oesophagus.

Distribution: Daihanratu in Formosa; Tinnanpo, Uturyô-tô, Zinsen,

Reisui and Gunzan in Korea; Onomiti Bay; Ariake Bay.

Remarks: This species was first described by IKEDA in 1904 dealing with a single specimen from Onomiti Bay. Afterwards it was reported by the writer from Ariake Bay.

Physcosoma onomichianum closely resembles *Physcosoma gaudens* which was reported from Malay Peninsula by W. LANCHESTER in 1905. But the description of the latter species is not so complete as to be referred to the present specimens. The writer, therefore, identified the specimens at my hand with *Physcosoma onomichianum.*

This species has been hitherto known as a sub-tropical form, being found in Onomiti Bay and Ariake Bay. From the tropical sea, such as Daihanratu in Formosa, it was taken for the first time.

46. Physcosoma formosense, n. sp.
(Pl. XX, Fig. 15; Text-fig. 36-41,

Two specimens of this new species were collected at Suô in Formosa on the 13th of March, 1936. They are rather small in size.

In one specimen (Pl. XX, Fig. 15) which is selected as the type, the body measures about 45 mm in total length and about 5 mm in diameter at the widest part. The introvert is very long, being about three times as long as the trunk. The posterior end of the body is suddenly stunted, making a sharply pointed end.
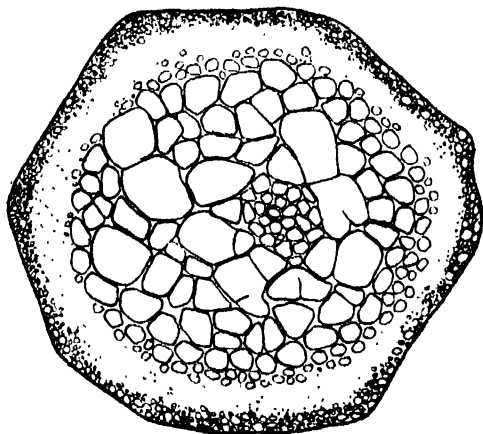
Text-fig. 36. *Physcosoma formosense*, n. sp. A skin-papilla from the introvert-basis. (Surface view). ×290.

The ground colour of the body-wall is yellowish-brown; and both of the introvert-basis and the posterior end of the trunk, show a deep brown colour. In the region of the trunk, the skin is very thick and entirely opaque, while in that of the introvert it is thin.

The whole surface of the body is covered with numerous prominent skin-papillae of a deep brown colour (Text-figs. 36-38). Those found in the region of the introvert-basis (Text-fig. 36) are the largest

Text-fig. 37. *Physcosoma formosense*, n. sp. A piece of skin from the hooked region of introvert, showing the skin-papillae and the hooks. ×290.
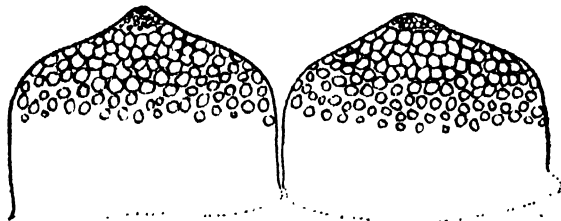
Text-fig. 38. *Physcosoma formosense*, n. sp. Two skin-papillae from the middle region of the trunk. (Side-view). ×145.

and those on the introvert (Text-fig. 37) are the smallest, as shown in the following table.

TABLE IX

	Height	Width
Small skin-papillae in the hooked region of introvert	0.014-0.016 mm	0.014-0.016 mm
Large skin-papillae in the hooked region of introvert	0.02 -0.035 mm	0.045-0.07 mm
Skin-papillae in the middle region of the introvert	0.08 -0.1 mm	0.1 -0.15 mm
Skin-papillae at the introvert-basis	0.25 -0.3 mm	0.2 -0.25 mm
Skin-papillae in the middle region of the trunk	0.15 -0.2 mm	0.15 -0.2 mm
Skin-papillae in the posterior region of the body	0.2 -0.25 mm	0.15 -0.2 mm

On the dorsal surface of the introvert there are a few number of hooks scattered (Text-fig. 39). Each hook is about 0.05 mm in height and is about 0.065 mm in width. In the hooked region of the introvert, there are found small skin-papillae mixed with larger ones as shown in the Text-fig. 37. Their dimensions are mentioned in the Table IX. Of these two kinds of skin-papillae the smaller ones are sphaerical in form, while the larger
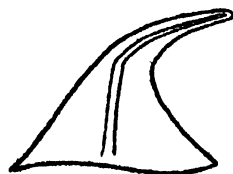
Text-fig. 39. *Physcosoma formosense*, n. sp. A hook from the introvert. (Side-view). ×435.

are rather flat. Tentacular crown consists of 22 tentacles, and each is finger-shaped (Text-fig. 40).
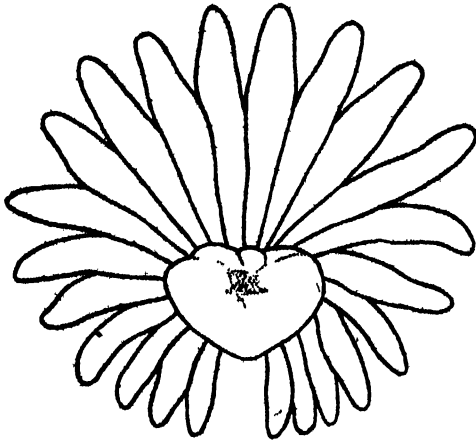
Text-fig 40.   *Physcosoma formosense,* n. sp Tentacular crown. (Frontral view) ×30.

The longitudinal muscle layer of the body-wall is divided into 30–40 separate bands. They are frequently anastomosed (Text-fig. 41, lm). In the region of the introvert these bands are entirely fused into a continuous sheet. The circular muscle layer is continuous.

Of the four retractor muscles, the ventral pair (Text-fig. 41, vr) are larger than the dorsal arising from the 3rd–10th longitudinal muscle-bands at the posterior end of the body; while the dorsal pair (Text-fig. 41, dr) arise far anteriorly from the 5th–6th longitudinal muscle bands. A spindle-muscle (Text-fig. 41, sm) springs in front of the anus and fixes the intestine to the body-wall at the posterior end of the trunk. There is a single fixing-muscle which arises from the first longitudinal muscle band on the left side of the trunk, and is attached to the intestinal convolution at the point where the intestine begins to coil. A pair of wing-muscles (Text-fig. 41, wm) are attached to the lateral sides of the rectum near the anus. The intestinal convolution (Text-fig. 41, i) consists of about 10 spirals and its posterior end is fixed to the trunk by means of the spindle-muscle. No diverticulum is present upon the rectum. The anus (Text-fig. 41, a) is situated slightly behind the external apertures of the segmental organs. The segmental organ (Text-fig. 41, so) consists of two sacs of a yellowish-gray colour and each is furnished with a large protuberance at the anterior end. Their external apertures lie between the 5th and 6th longitudinal muscle-bands. The anterior half of each organ is fixed to the body-wall by means of a mesentery.

Distribution: Suô in Formosa.

Remarks: This new species resembles both *Physcosoma nigritorquatum* (Sluiter) and *Physcosoma falcidentatum* (Sluiter) in the presence of very few number of hooks on the introvert. It, however, differs from these

two species in the shape of hooks as well as in the position of the attachment-base of the retractor muscles.

In the shape of hooks found on the introvert, this new species is somewhat allied to *Physcosoma japonicum* (GRUBE) and *Physcosoma glaucum* SATÔ, but it is markedly differs from these in the number of hook-rows and in the features of the skin-papillae.

Genus PHASCOLOSOMA F. S. LEUCKART

The longitudinal muscle layer is continuous. Tentacles are filamentous or leaf-like, and encircle the mouth being arranged in one or many rows or in groups. Hooks may or may not be present on the introvert. Two or four retractor muscles are present. Generally

Text-fig. 41. *Physcosoma formosense*, n. sp. Specimen dissected. a, anus; dr, dorsal retractor muscles; i, intestinal convolution; in, introvert; lm, longitudinal muscle-band; n, ventral nerve-cord; o, oesophagus; r, rectum; sm, spindle-muscle; so, segmental organ; vr, ventral retractor muscles; wm, wing-muscles. ×3.

a spindle-muscle is also present. The anterior portion of the intestinal convolution is fixed to the body-wall by one or more fixing-muscles, while its posterior end is usually free from the body-wall. There are two segmental organs. The skin-papillae are small in most species.

47. Phascolosoma vulgare (DE BLAINVILLE)
(Pls. XXI, XXIII, Figs. 17, 35; Text-figs. 42-43)

Sipunculus vulgaris, DE BLAINVILLE, 1827, pp 312 313, Pl. 33, Fig. 3.

Phascolosoma vulgare (DE BLAINVILLE), KEFERSTEIN, 1862, p. 39, Taf. III. Fig. 3; 1865,
    p. 429, Taf. XXXI, Fig. 5; 1865, p. 189; BAIRD, 1868, p. 84; SELENKA, 1883,
    pp. 20 23, Taf. I, Fig. 1; Taf. III, Figs. 25 34; 1885, pp. 10 11; PRUVOT,
    1897, p. 594; SLUITER, 1900, p. 13; 1912, p. 7, Pl. I, Fig 1; AUGENER,
    1903, pp. 297-371; THÉEL, 1904, pp. 60 62, Pl. I, Figs. 1-5; Pl. II, Fig. 14;
    Pl. XIII, Fig 186; LANCHESTER, 1905, pp. 27-28; SOUTHERN, 1913, pp. 1-46;
    1913, p. 6; J. FISCHER, 1914, pp. 94 95; W. FISCHER, 1895, p. 15; CUÉNOT,
    1922, pp. 6-8, Text-fig. 2; HÉRUBEL, 1925, pp. 260-263; STIASNY, 1930, p.
    212; WESENBERG LUND, 1933, pp. 3 5; SATÔ, 1937, pp. 151 153, Pl. III,
    Fig. 10.

Two specimens of this species are contained in the present collection.
Of these two, one was taken from Formosa and the other was obtained
from Korea.

In the specimen from Formosa (Pl. XXI, Fig. 17), which lived in the
coral sand such as to be exposed when it is low tide, is rather small in
size, measuring about 20 mm in trunk-length and about 5 mm in width
of the trunk. The introvert is much shorter and narrower than the
trunk, measuring about 6 mm in length and about 2 mm in width.

The remaining specimen (Pl. XXIII, Fig. 35), which was obtained from
the muddy bottom at Wandô in Korea on Sept. 2, 1937, is moderate in
size measuring about 35 mm in length and about 8 mm in thickness of
the trunk. The introvert is much narrower than the trunk being
nearly half as long as the trunk.

The skin appears smooth to the naked eye, but there are found
many small skin-papillae when observed under the microscope. The
greater part of the body-surface of the trunk is grayish white bearing
pearly lustre. In both of the introvert-basis and the posterior
region of the body, the skin shows grayish-yellow colour. In the main
part of the skin-surface of the trunk, the skin-papillae are very
small and low, and are not elevated
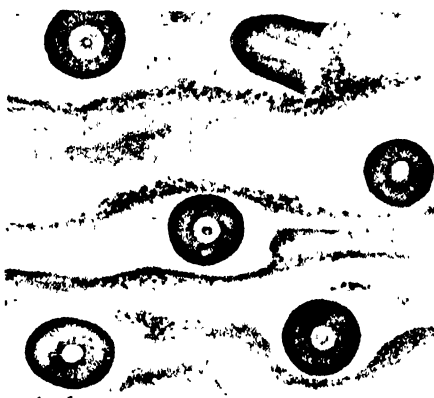
Text-fig. 42. *Phascolosoma vulgare* (DE BLAINVILLE). A piece of skin from the posterior region of the trunk, showing the skin-papillae. ×290.

on the skin-surface. In both of the introvert-basis and the posterior region of the body, the skin-papillae are roundish. They measure 0.03 0.04 mm in height and 0.02–0.04 mm in width of the base (Text fig. 42).

At the anterior end of the introvert, behind the tentacular crown, there are found numerous spines scattered very irregularly. They are dark brown in colour and are bluntly pointed at the top (Text-fig. 43, A–C).

A   B   C
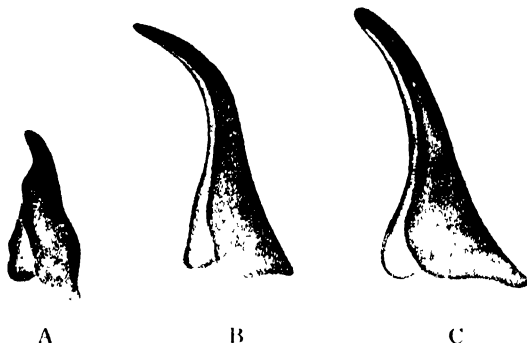
Text-fig. 43. *Phascolosoma vulgare* (DE. BLAINVILLE). Spines from the introvert. (Side-view). A, a spine found at the posterior part of the spined region; B, a spine found in the middle part of the spined region; C, a spine found at the anterior part of the spined region. ×290.

Each of these spines has a slightly curved apical tooth, measuring 0.06–0.15 mm in height. The tentacles are filamentous and numerous.

The longitudinal muscle layer of the body-wall is continuous. The inner surface of the skin shows a pearly lustre. Two pairs of slender retractor muscles are present. The ventral pair arise in the middle of the trunk, while the dorsal pair arise far anteriorly. Of these two pairs of the muscles, the dorsal are narrower than the ventral. A single stout spindle-muscle arises from a point located near the anus, and its posterior extremity is set from the body-wall. There are three slender fixing-muscles. They all rise from the body-wall and their end is attached to the anterior portion of the intestinal convolution. Well-developed wing-muscles are found attached to the rectum near the anus. The intestinal convolution which coils around the spindle-muscle, consists of about 30 spirals. It is free from the body-wall posteriorly. No polian tubule is found on the polian canal which passes along the dorsal side of the oesophagus. A pair of segmental organs are present. They are tubes

of comparatively long and of grayish colour, and hung free into the body-cavity. The external apertures of these organs are situated almost at the same level with the anus.

Distribution:

In Japan: Off Hutago-zima in Mutsu Bay; Daihanratu in Formosa; Off Hudai, on the Pacific coast of North Japan; Wandô in Korea.

Foreign: Dieppe; St. Vaast; Roscoff; St. Malo; Nordsee; England; Bergen; Bergensfjord; St. Tropez; Tor; Bay of Ferrol; Santa-Luzia; West coast of Scandinavia; Greenland; Helgoland; Nizza; Villa France; Irland; Coast of Maroc; Singapore; Malacca; Mediterranean Sea; Belgium.

Remarks: One variety of this species, *Phascolosoma vulgare* var. *tropicum*, has been reported by the writer (1934, pp. 3–5, Text-figs. 1–4) dealing with a single specimen obtained at a depth of 170 meters off Hudai a small village on the Pacific coast of North Japan.

48. Phascolosoma pyriformis LANCHESTER
(Pl. XXI, Fig. 16; Text-figs. 44 45)

Many specimens of this species were taken at Hattosi in Formosa and also at Miyako and Naha in Riukiu Islands. They were discovered under the stones lying between the tide-marks.

In the preserved state, the animal is pyriform in shape (Pl. XXI, Fig. 16). In a specimen of moderate size (in contracted condition), the trunk measures about 15 mm in length and about 9 mm in diameter at the widest part. The introvert is considerably shorter than the trunk.

The ground colour of the skin is yellowish orange, but the posterior region of the trunk appears somewhat grayish white. The body-wall is thick and entirely opaque. The outer surface of the body-wall is nearly smooth to the naked eye, but there can be detected numerous small skin-papillae when observed under high magnification. The skin-papillae (Text-fig. 44) are peculiar in form. Each of these skin-papillae is low and bears a wide central opening leading into the internal epidermis passing through a straight duct. Neither

Text-fig. 44 *Phascolosoma pyriformis* LANCHESTER. A skin-papillae from the middle region of trunk. (Surface-view). ×435.

hook nor spine is found on the introvert. Tentacles are filamentous and are numerous in number.

The longitudinal muscle layer of the body-wall is continuous. The inner surface of the muscle is very smooth and lustrous. The retractor muscles (Text-fig. 45, rm) consists of a single pair. They are broad and short, being attached to the body-wall at the level of the posterior one-third of the trunk-length. A stout spindle-muscle (Text-fig. 45, sm) arises near the anus and its posterior extremity is set free from the body-wall. Two fixing-muscles (Text-fig. 45, fm) are present. One of these muscles springs from the body-wall near the left segmental organ and is attached
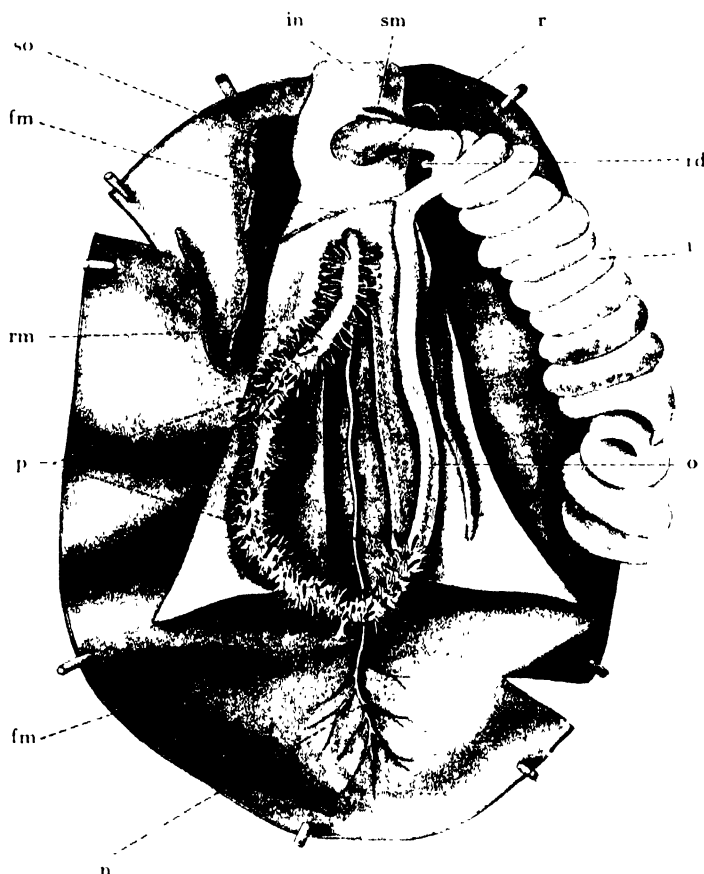
Text-fig. 45. *Phascolosoma pyriformis* LANCHESTER. Specimen dissected. fm, fixing-muscle; i, intestinal convolution; in, introvert; n, ventral nerve-cord; o, oesophagus; pt, polian tubules; r, rectum; rd, rectal diverticulum; rm, retractor muscle; sm, spindle-muscle; so, segmental organ. ×7.

to the oesophagus near the beginning of the intestinal convolution. The remaining one arises from the body-wall on the left side of the ventral nerve-cord near the roots of the left retractor muscle, and is attached to the middle portion of the oesophagus.

The intestinal convolution (Text-fig. 45, i) which coils around the spindle-muscle, consists of 10–15 spirals. It is free from the body-wall posteriorly. The oesophagus (Text-fig. 45, o) is furnished with numerous polian tubules, first extending backwards to the hind end of the body, and then turns forwards to form the intestinal convolution at the anterior end of the trunk. Two long segmental organs (Text-fig. 45, so) of a yellowish-gray colour are present. They are entirely free from the body-wall. The external apertures of these organs are situated on the introvert almost at the same level with the anus. A small rectal diverticulum (Text-fig. 45, rd) is found on the rectum. The ventral nerve-cord (Text-fig. 45, n) gives off several branches at the posterior end of the body.

Distribution :

In Japan : Hattosi in Formosa ; Miyako and Naha in Riukiu Islands.

Foreign : Pulau Bidan, Penang.

Remarks : As it was pointed out by LANCHESTER (1905, p. 39), the most peculiar characteristic of this species is that both of the anus and the segmental organs open on the introvert.

49. Phascolosoma catharinae F. MÜLLER
(Pl. XXIII, Figs. 36–37)

Phascolosoma catharinae, F. MÜLLER, 1868, p. 48; E. SELENKA, 1883, pp 38–39, Taf. II, Fig. 16, Taf V, Figs. 60–63; 1885, p 13; COLLIN, 1892, p. 177; SLUITER, 1912, p. 8; TEN BROEKE, 1925, pp. 3–4; SATÔ. 1937, pp. 154–155, Pl. III, Fig. 13.

This species is represented by ten specimens in the present collection. Of these ten, nine were obtained at the muddy beach of Moppo in Korea, while the remaining one was secured at Wandô in Korea together with *Thalassema mucosum*.

Of these specimens, mentioned above, the largest specimen measures about 40 mm in trunk-length and the introvert is about half as long as the trunk-length.

The animals in life are coiled more or less spirally. The posterior end of the trunk is conically pointed.

The skin is gray, but both of the introvert and the introvert-basis

look brown. In the smaller specimens, it is not distinct. The surface of the skin appears nearly smooth to the naked eye, but under the microscope it looks rough, being covered with small skin-papillae. They are scattered very sparsely, each being cylindrical in form. The measurements of the skin-papillae are shown in the following table.

TABLE   X

*The measurements of the skin-papillae of
Phascolosoma catharinae*

	Height	Width
Skin-papillae found on introvert-basis	0.04–0.05 mm	0.02 –0.03 mm
The same on the middle region of trunk	0.04–0.05 mm	0.02 –0.03 mm
The same at posterior region of trunk	0.07–0.08 mm	0.025–0.03 mm

Both of the longitudinal and the circular muscle layer are continuous. The inner surface of the body-wall is smooth and lustrous. The retractor muscles are set in a single pair, and are attached to the body-wall at a level of the posterior one-third of the trunk-length. A spindle-muscle which arises from the wall of the rectum, is not attached to the body-wall posteriorly. There is only one fixing-muscle which is very fine and attached to the anterior portion of the intestine. The intestinal convolution consists of about 20 spirals, and it is not fixed to the posterior end of the trunk. The polian canal passes along the dorsal surface of the oesophagus, giving off a great number of short blind tubules on its way. Two segmental organs of grayish-brown colour are present. They hang free into the body-cavity. The external apertures of these organs are situated slightly in front of the anus. No rectal diverticulum is detected upon the rectum.

Distribution:

In Japan: Moppo and Wandô in Korea; Onagawa Bay.

Foreign: Desterro; Callao; Pico-Fayal; West India.

Remarks: The present specimens somewhat resemble *Phascolosoma semperi* in both of general form and the number of the fixing-muscles, but the latter differs from the former in the form and dimension of the skin-papillae.

This species is one of the tropical forms, however it was reported from North Japan (Onagawa Bay) by the writer in 1937.

50. Phascolosoma owstoni IKEDA

Phascolosoma owstoni IKEDA, 1904, pp. 12–15, Figs. 5, 39–44.

Distribution: Uraga Channel.

51. Phascolosoma okinoseanum IKEDA

Phascolosoma okinoseanum IKEDA, 1904, pp. 9–12, Figs. 4, 34–38.

Distribution: Sagami Sea.

52. Phascolosoma appendiculatum SATÔ

Phascolosoma appendiculatum SATÔ, 1934, pp. 7–10, Pl. I, Fig. 4, Text-figs. 7 10.

Distribution: Tosa Bay.

Remarks: This species closely resembles *Phascolosoma flagriferum* and *Phascolosoma hudsonianum,* in presence of the characteristic caudal appendage. But it differs from the first species in the number of retractor muscles, and from the second in the shape of the skin-papillae and in the situation of the attachment point of the retractor muscles to the body-wall.

53. Phascolosoma glossipapillosum SATÔ

Phascolosoma glossipapillosum SATÔ, 1934, pp. 10–12, Pl. I, Fig. 5, Text-figs. 11 14.

Distribution: Off Hamada (Province of Iwami) Japan Sea.

54. Phascolosoma japonicum IKEDA

Phascolosoma japonicum IKEDA, 1904, pp. 5–7, Figs. 2, 28–29.

Distribution: Tokyô Bay and Sagami Bay.

55. Phascolosoma signum SATÔ

Phascolosoma signum SATÔ, 1934, pp. 16–17, Pl. I, Fig. 8, Text-fig. 18.

Distribution: Wakasa Bay.

56. Phascolosoma margaritaceum (SARS)

Phascolosoma margaritaceus SARS, 1851, Nyt Magazin for Naturvidenskaberne, VI. Bd., Christiana. pp. 196–197.

Homalosoma laeve OERSTED, KEFERSTEIN, 1865, p. 436.

Phascolosoma oerstedii KEFERSTEIN, 1865, pp. 205–206; 1865, p. 436, Taf. XXXI, Fig. 8, Taf. XXXIII, Fig. 39; VON HEUGLIN, 1870–1871, p. 246.

Phascolosoma albidum THÉEL, 1875, p. 8, Pl. II, Fig. 10; KOREN & DANIELSSEN, 1877 p. 154.

Phascolosoma fulgens THÉEL, p. 8, Pl. II, Fig. 11.

Phascolosoma margaritaceum (SARS), KOREN & DANIELSSEN, 1877, pp. 135-136, Taf. XV, Fig. 43-44; THÉEL, 1904, pp. 63-65, Pl. III, Figs. 29-33, Pl. IV, Figs. 34-37, Pl. XII, Fig. 174, Pl. XIV, Figs. 192-196.

Distribution :

In Japan : A variety of this species, *Phascolosoma margaritaceum* var. *antarcticum* MICHAELSEN, has been reported by the writer the specimen being obtained from a depth of 172 meters off the west coast of Noto Peninsula.

Foreign : Greenland ; Spitzbergen ; Finmarken ; Kola Peninsula ; Novaya Zemlya ; Bering Strait.

Remarks : THÉEL (1904, p. 63) has divided this species into two forms, namely, *Forma finmarchia* and *Forma sibirica.* He noted that : — " The species in question is evidently subject to rather considerable variations, especially with regard to the number of the tentacles and the structure of the skin. For the present, therefore, I think it is desirable to keep apart two forms a westerly one, *Forma finmarchia*, and an easterly one, *Forma sibirica.* Nevertheless, they may very likely be representatives of the same species."

57. Phascolosoma soyo SATÔ

Phascolosoma soyo SATÔ, 1934, pp. 17-20, Pl. I, Fig. 9, Text-figs. 19-21.

Distribution : Off Mikuni (Hukui Prefecture), Japan Sea ; Off Mikkaiti (Toyama Prefecture), Japan Sea ; Tugaru Strait. This species is deep-sea form being obtained from the depth of 110–552 meters.

58. Phascolosoma noto SATÔ

Phscolosoma noto SATÔ, 1934, pp. 14-16, Pl. I, Fig. 7, Text-fig. 17.

Distribution : Off Noto Peninsula, Japan Sea (424 meters depth).

59. Phascolosoma nigrum IKEDA

Phascolosoma nigrum IKEDA, 1904, pp. 3-5, Figs. 1, 25-27; SATÔ, 1934, p. 247.

Distribution : This species is one of the commonest Sipunculids to be met with at the coasts of the Tokyô Bay, the Sagami Bay, the Ômuta Bay, and the Inland Sea.

Remarks : The animal lives in shallow muddy bottom, especially in

small inlets into which fresh-water finds egress.   The body in life is coiled
more or less in a spirally, and the greater part of the body is dark gray
or bluish black in colour except the tentacular basis of the introvert which
is light brown.   The total length of the body is 70–100 mm.   The introvert
is nearly $2^1/_2$ times as long as the trunk.

60.   Phascolosoma hyugense SATÔ

Phascolosoma hyugense SATÔ, 1934, pp. 12-14, Pl. I, Fig. 6, Text-figs. 15–16.

Distribution: Off Miyazaki (Province of Hyûga), Kyûsyû, Japan.
(The specimen was taken from the depth of 472 meters).

61..   Phascolosoma hozawai SATÔ

Phascolosoma hozawai SATÔ, 1937, pp. 158-160, Pl. IV, Fig. 15, Text-figs. 5-8.

Distribution: Miyato-zima (Miyagi Prefecture).

62.   Phascolosoma zenibakense IKEDA

Phascolosoma zenibakense IKEDA, 1924, pp. 29-30, Fig. 1; SATÔ, 1930, pp. 17-20, Pl. III,
Figs. 11 12, Text-fig. 5; 1937, pp. 153-154.

Distribution: Mutsu Bay (Aomori Prefecture); Takada (Iwate Pre-
fecture); Karakuwa (Miyagi Prefecture); Onagawa (Miyagi Prefecture);
Hokkaidô.

Remarks: This species is very common in the seas of the North
Japan.

63.   Phascolosoma onagawa SATÔ

Phascolosoma onagawa SATÔ, 1937, pp. 15ˉ-158, Pl. IV, Fig. 14, Text-figs. 3-4.

Distribution: Onagawa Bay (Miyagi Prefecture).

64.   Phascolosoma misakianum IKEDA

Phascolosoma misakianum IKEDA, 1904, pp. 7-9, Figs. 3, 30-33.

Distribution: Misaki.

Genus DENDROSTOMA GRUBE

The longitudinal muscle layer of the body-wall is continuous.   4–6
dendritic tentacular stems surround the mouth.   Two or four retractor
muscles, and one spindle-muscle are present.   There are two segmental

organs, free from the body-wall excepting for the attachment base.   The dermal papillae are small.

65.   Dendrostoma ellipticum Satô

Dendrostoma ellipticum Satô; 1934, pp. 20–22, Pl. I, Fig. 10. Text-figs. 22 25.

Distribution: Suruga Bay.

66.   Dendrostoma tropicum Satô

Dendrostoma tropicum Satô, 1935, pp. 313–315, Pl. IV, Fig. 15, Text-fig. 11.

Distribution: Yap Island.

67.   Dendrostoma minor Ikeda

• *Dendrostoma minor* Ikeda, 1904, pp. 57–58, Figs. 16, 92–95.

Distribution: Hunakawa (Province of Ugo); Misaki ; Ôsima (Province of Izu); Tanegasima (Kagosima Prefecture).

68.   Dendrostoma signifer Selenka & De Man

Dendrostoma signifer Selenka & De Man, 1884, pp. 86–87, Taf. II, Fig. 21, Taf. XI, Figs. 163-169; Sluiter, 1890, p. 115; 1902; Ikeda, 1904, pp. 56 57, Fig. 15; Fischer, 1890, p. 17; 1914, pp. 59-84; 1914, pp. 1–28; 1919, pp. 277 285, 1922; 1926, p. 206.

Distribution:

In Japan: Riukiu Islands.

Foreign: Philippine ; Singapore ; Cap York ; Batavia ; Billiton ; Tausend-Inseln ; Albany Bezirk.

Remarks: This tropical form was first described by Selenka & De Man in 1884, using the specimens came from Philippine, Singapore and Cap York.   In Japanese waters, it has been reported by Ikeda in 1904 from Riukiu Islands.   But none of the specimens of this species have been obtained by the writer during the collections made at the various localities distributed in Japanese waters.

69.   Dendrostoma blandum Selenka & De Man

Dendrostoma blandum, Selenka et De Man, 1883-1885, p. 85, Pl. I, Fig. 9; Pl. XI, Figs. 159-162; 1885, p. 14; I. Ikeda, 1904, p. 54, Pl. I, Fig. 14; Pl. IV, Figs. 90-91; 1924, p. 30, Pl. I, Fig. 2; A. Ostroumov, 1909, pp. 319-324; W. Fischer, 1922, p. 18; H. Satô, 1930, pp. 24-28, Pl. IV, Text-figs. 10-12; 1937, p. 162, Pl. IV, Fig. 16.

Distribution :

In Japan : This species is rather commonly found along the coast of North Japan, viz: Mutsu Bay (Aomori Prefecture); Onagawa Bay (Miyagi Prefecture), Hokkaidô. But the species has been exceptionally reported by SELENKA & DE MAN from Enosima.

Foreign : California.

70. Dendrostoma hexadactylum SATÔ

Dendrostoma hexadactylum SATÔ, 1930, pp. 28–33, Pl. IV, Figs. 20–24, Text-figs. 13–15; 1937, pp. 162–163, Pl. IV, Fig. 17.

This large Sipunculid which attains up to 180 mm in body-length, is commonly obtainable along the coast of North Japan.

The animals are usually found under large stones or under the seaweeds grown on the tufaceous sandstone.

Distributions : Mutsu Bay (Aomori Prefecture); Takada (Iwate Prefecture); Ôya (Miyagi Prefecture); Karakuwa (Miyagi Prefecture); Akkes¹ (Hokkaidô).

Remarks : This species closely resembles *Dendrostoma blandum* SELENKA & DE MAN in the external form of the body, and in the internal structures, but, however, it differs from the latter in the height of the skin-papillae found in the hooked region of the introvert and in the features of the tentacular crown, viz., the number of the main tentacular stems is six in the present species, while in *Dendrostoma blandum* it is usually four.

Genus PHASCOLION THÉEL

The longitudinal muscle layer of the body-wall is perfectly continuous. There is only one segmental organ. One or two retractor muscles are present. A single row of tentacles exist around the mouth. Numerous, recurved small spines often occur in a zone behind the tentacles. In most species, numerous attaching papillae, each of which is capped with one or more spines, are arranged in a broad band encircling the body. The body is generally twisted into spirals. The worms usually inhabit the shells of Gastropods or Scaphopods, but sometimes they also live in the tubes of Annelids or in those constructed by themselves.

71.　Phascolion ikedai SATÓ

Phascolion ikedai SATO, 1930, pp. 20-23, Pl III, Fig 13-17, Text-figs. 6-9, 1937, pp. 163-165, Pl. IV, Figs. 18-19; Text-fig. 9.

Distribution:　Mutsu Bay (Aomori Prefecture); Kuwahama (Miyagi Prefecture); Onagawa Bay (Miyagi Prefecture).

Remarks:　This animal is very small and lives in a state of commensalism with a Madreporarian coral, *Heterocyathus japonicus* (VERRILL).

72.　Phascolion dentalicola SATÓ

Phascolion dentalicola SATÓ, 1937, pp 165-167, Pl IV, Figs. 20-21, Text figs 10-11

Distribution:　Onagawa Bay (Miyagi Prefecture).

73.　Phascolion rectus IKEDA

Phascolion rectus IKEDA, 1904, pp. 15-18, Figs 15-19

Distribution:　Sagami Bay (A single specimen was obtained from a depth of 100 fathoms).

74.　Phascolion artificiosus IKEDA

Phascolion artificiosus IKEDA, 1904, pp. 18-20, Figs 6, 50-55

Distribution:　Sagami Bay (Two specimens were collected from a depth of 100 fathoms).

75.　Phascolion lucifugax SELENKA & DE MAN

Phascolion lucifugax SELENKA & DE MAN, 1883, pp. 13-14, Taf V, Figs 61-66

Distribution:
　　In Japan:　Hakodate (Hokkaidô).
　　Foreign:　Panglao and Bohol (Philippine).

Remarks:　This species was described for the first time by SELENKA & DE MAN in 1883, using the specimens obtained from Japan and Philippine Archiperago. Concerning this species, no report has been done from the Japanese waters except for the SELENKA's monograph.

Genus ASPIDOSIPHON DIESING

A distinct shield-like appendage is present at both extremities of the trunk. The introvert is excentric, arising from the ventral side of the

anterior shield. Hooks generally present. Longitudinal muscle layer of the body-wall is either divided into bundles or perfectly continuous. Tropical or sub-tropical form.

76. Aspidosiphon grandis, n. sp.
(Pl. XXI, Fig. 21; Text-figs. 46–50)

The unique specimen (Pl. XXI, Fig. 21) on which this new species based was obtained from Daihanratu in Formosa on March 19, 1936, being found inside of a coral rock lying between the tide-marks.

The specimen is very large in size. In the preserved state in alcohol, the trunk measures about 70 mm in length and about 10 mm in maximum width.

The skin of the trunk is brownish yellow in colour, and becomes deeper towards the anal shield. In the anterior region of the trunk just behind the anal shield, the skin appears strongly dark brown since there are found a number of large skin-papillae as shown in the Text-figs. 46–48.

The anal shield (or anterior shield) is oval in shape and is of black colour. The surface of the shield is folded forming fifteen numbers of radial grooves. Only in the area near the aperture of the shield, through which the introvert may protrude, it exhibits granular structure. The surface of the shield is very stiff being composed of chitinous substance, and can not be detected any calcareous deposit on it. The caudal shield (Text-fig. 50, cs) which is conical in side-view, bears many grooves in radial arrangement. It is dark brown in colour.
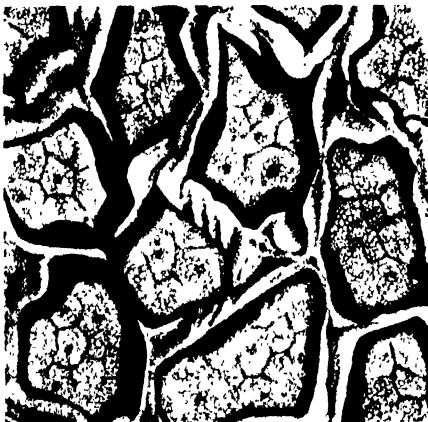
Text-fig. 46. *Aspidosiphon grandis*, n. sp. A piece of skin taken from the region located behind the anal shield, showing the skin-papillae. (Surface-view). ×35.

The surface of the trunk is provided with numerous skin-papillae (Text-figs. 46–48). Those found in the regions of both anterior and posterior extremities of the trunk, are remarkably large in size and are strongly pigmented. In the middle region of the trunk, however, the skin-papillae are

rather small low, being not pigmented. Each of the skin-papillae consists of several glands covered with a number of minute chitinous plates. The skin-papillae set on the anterior region of the trunk just behind the anal shield, are crowded, making a zone around the anterior part of the trunk. In this region, each of the skin-papillae is bounded by a dark pigment-rim (Text-figs. 46–47). The skin-papillae found in the posterior region of the trunk, are very similar to those set on the anterior region of the trunk. But the polygonal chitinous bodies found in the former are much larger and more pigmented than the latter as shown in the Text-figs. 46–48. In the middle region of the trunk the chitinous bodies which cover the skin-papillae are small and flat being almost colourless. They are not visible unless use high magnification. The skin-surface of

Text-fig. 47. *Aspidosiphon grandis*, n. sp. A greatly magnified view of the skin-papilla from the same region shown in the Text-fig 46. (Surface-view). × 75.

the introvert is strongly pigmented and is not found any kinds of papillae on it. In the hooked region of the introvert, we find small papillae which arranged in some regular transverse rows encircling the introvert. Each row exists between every two rows of hooks. The measurements of the skin-papillae are shown in the Table XI.

About 60 transverse rows of hooks are present behind the tentacles on the introvert. Each hook appears beak-shaped as shown in the Text-fig. 49. The hooks found on the anterior extremity of the introvert are tall being sharply pointed at the top, measuring 0.1 mm height and 0.07 mm in breadth at the base (Text-fig. 49, C). In the posterior part of
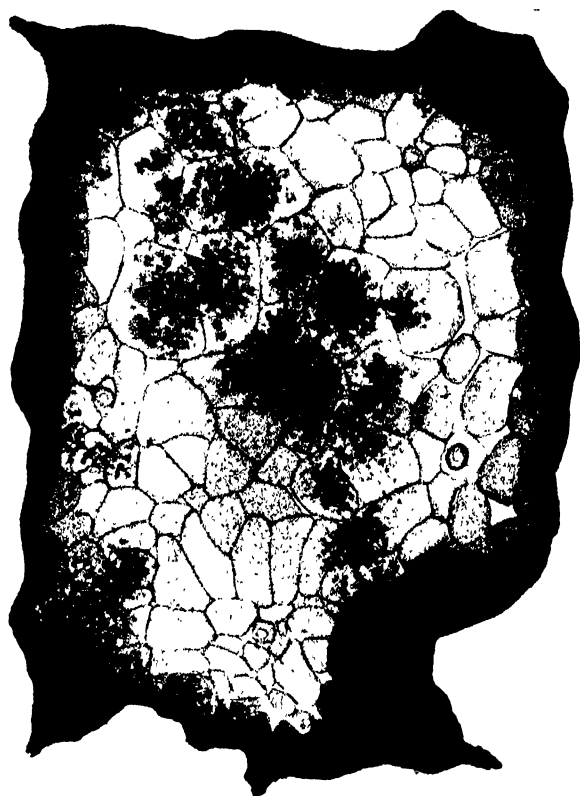
Text-fig. 48. *Aspidosiphon grandis,* n sp   A skin-papilla located
near the caudal shield. (Surface-view). ×75.

TABLE XI

	Height	Width
Skin-papillae found in the hooked region	0.02 0.025 mm	0 007 0 008 mm
Skin-papillae found in the anterior region just behind the anal shield	0.15–0.3 mm	0.035–0.06 mm
Skin-papillae found in the middle region of the trunk	0.05 0.1 mm	0.2 0.5 mm
Skin-papillae found in the posterior region of the trunk just in front of the caudal shield	0 15 0.3 mm	0.35 0.6 mm

the hooked region, each hook has bluntly pointed tip measuring about
0.08 mm in both height and breadth (Text-fig. 49, A). Tentacles are
filamentous and numerous being arranged radially around the mouth-
aperture.

Text-fig. 49. *Aspidosiphon grandis,* n. sp. Hooks from the introvert. A, A
hook found at the posterior part of the hooked region; B, A hook found in
the middle part of the hooked region; C, A hook found at the anterior part of
the hooked region × 290.

The longitudinal muscle layer of the body-wall (Text-fig. 50) is divided
into many separate bands, several of which being anatomosed. They are
about 28 in number in the middle of the trunk, while they are about 24
in the anterior region of the trunk. At the anterior end of the trunk,
the longitudinal muscle-bands are frequently anastomosed showing an ir-
regular net-work. In the region of the introvert, these bands are entirely
fused one another to form a continuous sheet. The circular muscle layer
is also splitted into numerous narrow bands.

A single broad retractor muscle is present. It arises from the body-
wall in the posterior region of the trunk as shown in the Text-fig. 50, rm.
The retractor muscle has four short roots. Of these four, each of the
two which stand close to the ventral nerve-cord is again divided into
two short roots. All these roots arise from almost the same level (Text-
fig. 50, rm). A spindle-muscle (Text-fig. 50, sm) springs from the body-
wall near the anus, and its posterior end is fixed to the posterior end of
the trunk. Fixing-muscles are absent. Wing-muscles are attached to the
rectum near the anus. The intestinal convolution (Text-fig. 50, i) consist-
ing of about 30 spirals coils around the spindle-muscle. The polian canal
is simple and is not provided with any tubules. The segmental organs
(Text-fig. 50, so) are long tubes of a brownish-yellow colour, and their
anterior half is attached to the body-wall by means of mesenteries. The
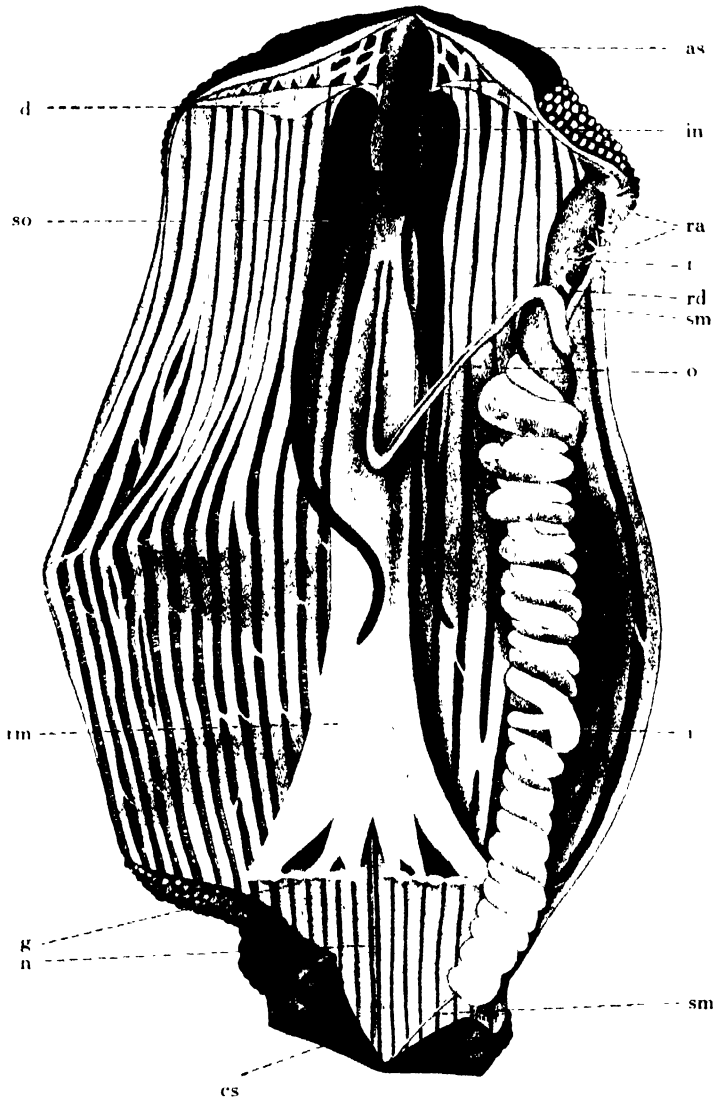
Text-fig. 50. *Aspidosiphon grandis*, n. sp. Specimen dissected. as, anal shield; cs, caudal shield; d, diaphragm; g, gonad; i, intestinal convolution; in, introvert; n, ventral nerve-cord; o, oesophagus; r, rectum; ra, short blind tubes attached to the rectum; rd, rectal diverticulum; rm, retractor muscle; sm, spindle-muscle; so, segmental organ. ×2

external apertures of these organs lie between the 2nd and 3rd longi-
tudinal muscle-bands. The anus is situated slightly behind the external
apertures of the segmental organs. The rectum (Text-fig. 50, r) bears
two sorts of appendixes. The one is a small diverticulum (Text-fig. 50,
rd) and the remaining one consists of many short blind tubes attached
to the both sides of the rectum (Text-fig. 50, ra). There is a sheet of
diaphragm stretching transversely in the body-cavity at the anterior region
of the trunk (Text-fig. 50, d).

Distribution : Daihanratu in Formosa.

Remarks : As the members of the genus *Aspidosiphon*, there were
hitherto known only three species which are characterized, as in the
present new species, by the possession of four roots of the retractor
muscle and by the possession of longitudinal muscle layer of the body-
wall separated into bands. They are *Aspidosiphon cumingii* BAIRD
(1868), *Aspidosiphon insularis* LANCHESTER (1905) and *Aspidosiphon
semperi* TEN BROEKE (1925).

Of these three species, *Aspidosiphon cumingii* closely resembles the
present new species both in general form and in the internal anatomy.
It may be, however, distinguished from this new species by the features
of the skin-papillae as well as by the number of hook-rows.

The present new species closely allied again with *Aspidosiphon pachy-
dermatus* which was recently described by WESENBERG-LUND (1937, pp.
9–16). But these two species in question may be distinguished from
each other by the different features of the skin-papillae as well as by
the difference in number of the roots of retractor muscle.

77. Aspidosiphon makoensis, n. sp.
(Pl. XXI, Fig. 22; Text-figs. 51–54)

Three specimens were collected at the shore of Makô in Formosa. They
were all found inside of dead coral-rock which was exposed at law tide.

The measurements of these three specimens are shown in the follow-
ing table.

TABLE XII

	Length of trunk	Width of trunk
No. 1. (Type specimen)	20 mm	3.5 mm
No. 2.	25 mm	3.8 mm
No. 3.	25 mm	3.8 mm

In the type specimen (Pl. XXI, Fig. 22), the surface of the trunk is yellowish-gray in colour and looks smooth to the nacked eye. The introvert, the greater part of which is withdrawn, measures about 10 mm in length.
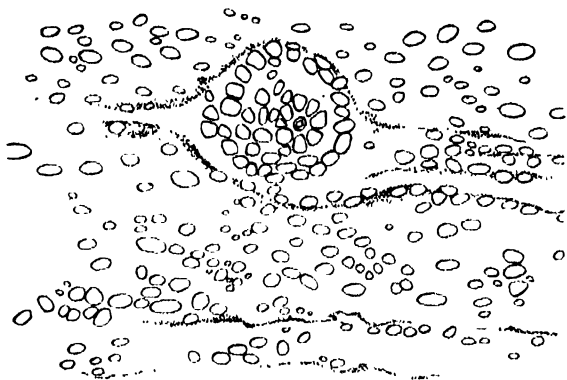
Text-fig. 51. *Aspidosiphon makoensis*, n. sp. A piece of skin from the middle region of the trunk, showing a skin-papilla and the arrangement of the chitinous bodies. ×290.

The anal shield (Text-fig. 54, as) is oval in form and is composed of many chitinous granules of a deep brown colour. No calcareous substance is attached to the shield. The caudal shield (Text-fig. 54, cs) is conical in side view and is roundish in surface view. It bears many grooves running radially. The skin-surface adjacent to each shield is closely beset with the skin-papillae (Text-figs. 51–52) arranged in many transverse rows. The skin-papillae found in the middle region of the trunk, are small in size. Each of these skin-papillae is covered by many small polygonal chitinous plates as shown in the Text-fig. 51. About 100 complete circular rows of hooks are present upon the anterior region of the introvert. Each of these hooks (Text-fig. 53) measures about 0.045 mm in height, and is supplied with two sharp teeth. Between every two rings of hooks, there are scattered minute tubular papillae.

Text-fig. 52. *Aspidosiphon makoensis*, n. sp. A skin-papilla from the anterior region of the trunk. (Surface-view). ×435.

Text-fig. 53. *Aspidosiphon makoensis*, n. sp. A hook from the introvert. (Side-view). ×435.

The longitudinal muscle layer of the body-wall is divided into 25–30 separate bands, but they are frequently anastomosed. There are only two retractor muscles which arise very close to the caudal shield. In the greater part of their length, they are fused into one band (Text-fig. 54, rm). A spindle muscle (Text-fig. 54, sm) which arises near the anus is fixed to the caudal end of the body.

No fixing-muscle is present. The intestinal convolution (Text-fig. 54, i) consists of about 13 spirals. The segmental organs (Text-fig. 54, so) are of long tubes, being half as long as the trunk-length. These organs are fixed throughout their whole length to the body-wall by means of mesentery (Text-fig. 54, m). The external aperture of each organ lies slightly behind the anus. The polian canal is simple and has not any tubules upon it.

Distribution: Makô in Formosa.

Remarks: Among the hitherto known *Aspidosiphon* species, *Aspidosiphon steenstrupii* seems to be very closely allied to the present new species. These two species in question, however, may be distinguished from each other by different features of the skin-papillae distributed on the surface of body, and by the difference in the position of attachment of the retractor muscles.
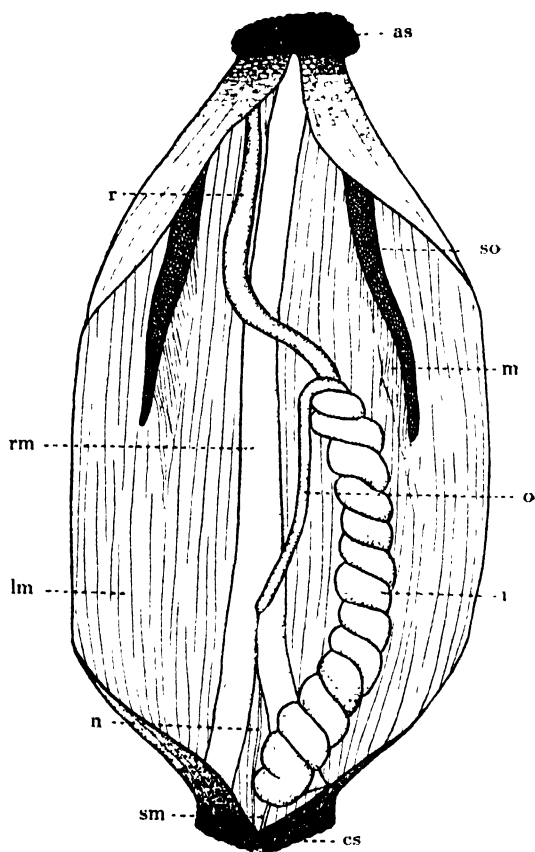
Text-fig. 54. *Aspidosiphon makoensis*, n. sp. Specimen dissected. as, anal shield; cs, caudal shield; i, intestinal convolution; lm, longitudinal muscle-band; m, mesentery; n, ventral nerve-cord; o, oesophagus; r, rectum; rm, retractor muscle; sm, spindle-muscle; so, segmental organ. ×4.

78. Aspidosiphon formosanus, n. sp.
(Pl. XXI, Fig. 23; Text-figs. 55-57)

Only two specimens of this new species were obtained at the shore of Sinkô in Formosa, from a coral-rock into which they had bored.

In the type specimen (Pl. XXI, Fig. 23), the trunk measures about

18 mm in length and 3 mm in breadth. The skin of the trunk is yellowish gray when preserved in alcohol.

The anal shield (Text-fig. 57, as), which is dark brown is colour, is oval in form. It is composed of minute chitinous granules, but the outer surface of the shield appears nearly smooth to the nacked eye. The ventral boader of the shield is unusually hard on account of the deposition of a calcareous substance. The caudal shield (Text-fig. 57, cs) is roundish and deep brown in colour. It is grooved radially and concentrically. When examined under microscope, the shield is seen to be constructed of many papillae which are similar to those of *Aspidosiphon steenstrupii* (Text-fig. 58).

The surface of the trunk is nearly smooth to the unaided eye, but there can be detected' numerous small skin-papillae when observed under microscope. Those found in the regions placed at both ends of the trunk, are larger and darker in colour than those located in the main part of the trunk. In the middle region of the trunk the skin-papillae are flat and small. Each of these skin-papillae is composed of a glandular structure covered with a number of small chitinous plates as shown in the Text-fig. 55.
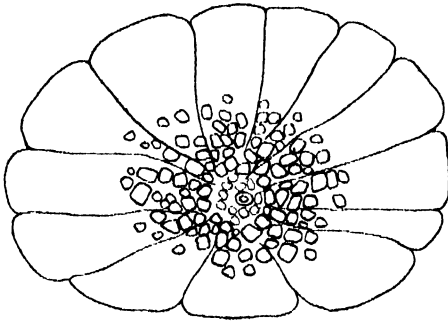
Text-fig. 55. *Aspidosiphon formosanus*, n. sp. A skin-papilla from the middle region of the trunk. (Surface-view). ×350.

A   B   C
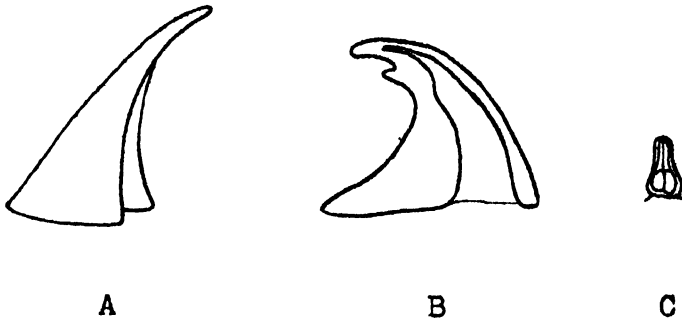
Text-fig. 56. *Aspidosiphon formosanus*, n. sp. A spine (A), a hook (B) and a small perforated skin-papilla (C) all taken from the introvert. (Side-view). ×580.

In the anterior region of the introvert, there are found about 30 circular hook-rows. Each hook (Text-fig. 56, B) is yellowish brown in colour, and is supplied with two teeth of bluntly pointed. It measures about 0.035 mm high and 0.05 mm broad. Behind the hook-rows above mentioned, there are distributed numerous gently curved spines (Text-fig. 56, A). They are about 0.06 mm in height.

The longitudinal muscle layer of the body-wall is divided into many bands which are frequently anastomosed (Text-fig. 57). The retractor muscles (Text-fig. 57, rm) are two in number. They arise from the body-wall just in front of the caudal shield (Text-fig. 57, cs). No fixing-muscles are present. The intestinal convolution (Text-fig. 57, i) consists of about 20 spirals. The posterior end of the convolution is fixed to the body-wall by means of spindle-muscle. There are two segmental organs (Text-fig. 57, so). They are long tubes being about two-thirds as long as the trunk. The anterior half of each organ is fixed to the body-wall

Text-fig. 57. *Aspidosiphon formosanus*, n. sp. Specimen dissected. as, anal shield; cs, caudal shield; i, intestinal convolution; m, mesentery; n, ventral nerve-cord; o, oesophagus; r, rectum; rm, retractor muscles: so, segmental organ. ×6.

by mesentery. The external apertures of the organs lie slightly behind the anus.

Distribution: Sinkô in Formosa.

Remarks: This new species closely resembles both of *Aspidosiphon
steenstrupii* and *Aspidosiphon makoensis*. But it differs from these two
species in the features of the retractor muscles and of the skin-papillae
found in the middle region of the trunk.

79.   Aspidosiphon steenstrupii DIESING
(Pl. XXI, XXIII, Figs. 18, 19, 44; Text-figs. 58–60)

Aspidosiphon steenstrupii, DIESING, 1895, Revision der Rhyngodeen, Sitzungsber. der
     Kön. zu Wien, mathemat. naturwiss. Cl. 37, p. 767, Tab. II, Figs. 1-6;
     SELENKA et DE MAN, 1883-1884, pp. 116-118, Taf. I, Figs. 12 13, Taf. XIII,
     Figs. 190-192; SLUITER, 1886, pp. 489-490, Taf. III, Figs. 5 6; 1890, p. 115;
     1902, p. 18; SHIPLEY, 1899, pp. 153 154; 1902, pp. 131-132; 1903, p. 171;
     AUGENER, 1903, pp. 297-371; IKEDA, 1904, pp. 40-41; 1924, p. 38; FISCHER,
     1914, pp. 1-28; 1914, pp. 59-84; 1922, pp. 23 24, Taf. II-III, Figs. 21-23;
     1926, p. 108; LANCHESTER, 1905, p. 39; TEN-BROEKE, 1925, pp. 13 14; SATÔ,
     1935, pp. 315-316, Pl. IV, Fig. 16.

This species is represented by many specimens in the present collec-
tion. They were obtained from various localities as shown in the follow-
ing table.

TABLE   XIII

Localities	Date	Collector
Daihanratu in Formosa	March 19, 1936	H. SATÔ
Nekobana in Formosa	March 20, 1936	,,
Wandô in Korea	Sept. 5, 1937	,,
Miyako in Riukiu Islands	April 5, 1936	,,

Of these specimens mentioned above, the larger one which was taken
from Korea (Pl. XXIII, Fig. 44) measures about 40 mm in the body-length;
while the smallest one which was obtained from Formosa (Pl. XXI, Fig. 18)
is only about 10 mm in the same.

The worms were found within a certain rock into which they had
bored.

The skin of the trunk is yellowish gray in the specimens preserved
in alcohol. The anal shield is oval in form, and is composed of small
chitinous bodies of a deep brown colour. It is covered with many white
dots. In some specimens came from Formosa, there exist a calcareous
deposit in the centre of the shield. The caudal shield, which is conical
in side view and is roundish in surface view, bears many grooves radially

arranged.   When examine this structure under microscope, it may be observed that the surface is covered with numerous small chitinous bodies of deep brown colour (Text-fig. 58).   On the outer surface of the trunk there are found many skin-papillae.   They are flat and somewhat elliptical in the surface view.   Each of these papillae is covered with numerous polygonal chitinous plates, and bears several perforations on its surface.

The introvert, which is light brown in colour, is much narrower and slightly shorter than the trunk.   The anterior portion of the introvert carries about 40 complete rings of hooks.   Each of these hooks (Text-fig. 59) is about 0.06 mm high and is supplied with two sharp teeth. Between every two rings of hooks there are scattered minute tubular papillae.   Behind these hook-rings, there are distributed numerous spines. These spines vary in size and their feature is as shown in the Text-fig. 60, A–C.

Text-fig. 59.   Aspidosiphon steenstrupii DIESING.   A hook taken from the introvert. (Side-view). × 435.

A   B   C
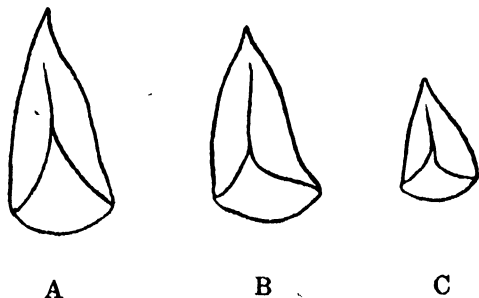
Text-fig. 60.   Aspidosiphon steenstrupii DIE-SING.   Spines from the introvert. (Frontal view). A, a spine found at the anterior part of the spine-region; B, a spine found at the middle part of the spine-region; C, a spine found at the posterior part of the spined region. × 435.

Text-fig. 58.   Aspidosiphon steenstrupii DIESING.   A part of the caudal shield, showing the arrangement of the chitinous bodies. ×74.

The longitudinal muscle layer of the trunk is divided into 20–30 bundles, several of which being anastomosed. Two retractor muscles rise from the body-wall at the level of the posterior one-fourth of the trunk-length. A spindle muscle which springs from the anterior extremity of the trunk is fixed to the caudal. end of the body. A single fixing-muscle arising from the body-wall, is attached to the alimentary canal with two branches; one of which is fixed to the hindmost part of the oesophagus, while the remaining one is joined to the spindle-muscle just at the beginning of the intestinal convolution. The intestinal convolution consists of 15–20 spirals. The segmental organs are two in number, each of which consisting of a short tube. The half length of the organ is attached to the body-wall by mesentery. Their external apertures lie slightly behind the anus.

Distribution:

In Japan: Riukiu Island; Formosa; Korea; Angauru; Jaluit; Yap.

Foreign: Mindanao; Mauritius; Java; Indian Archipelago; Loyalty Islands; Bahamas; Laccadive Islands; Brasil; West-Africa; New-Guinea; West India; Malay Peninsula.

Remarks: This species is one of the commonest Sipunculid found in the tropical sea of the Pacific Ocean.

SELENKA (1884, p. 117) stated in his monograph, that: — "Segmental organe sind zur Hälfte frei und erstrecken sich im ausgestreckten Zustande bis zur Basis der Retractoren". In the present specimen, however, the segmental organs are short and do not reach the roots of the retractor muscle.

Regarding the fixing-muscle, it may be pointed out, as already noted by IKEDA in the case of the specimens obtained from Riukiu that the muscle terminates in the intestine bifurcating into two branches; one of these branches is attached to the hindmost part of the oesophagus, and the other is jointed to the spindle-muscle just at the beginning of the intestinal convolution.

80. Aspidosiphon elegans (CHAMISSO et EYSENHARDT)
(Pl. XXI, Fig. 20)

Sternaspis elegans CHAMISSO et EYSENHARDT, 1821, De Animalibus quibus dans e classe vermium Linneana. Nova acta Academiae Caesareae Leopol.-Carolinae naturae curiosorum, Tomi X, p. 351.

Aspidosiphon elegans (CHAMISSO et EYSENHARDT), SELENKA et DE MAN, 1884, pp. 124–

125, Taf. I, Fig. 10; Taf. XIV, Figs. 205–208; SLUITER, 1890, p. 116; 1902, p. 19; SHIPLEY, 1898, p. 471, Pl. XXXVII, Fig. 8; 1899, p. 153; 1899, p. 531; LANCHESTER, 1905, p. 33; 1905, p. 40; FISCHER, 1914, pp. 1 28, Taf. I, Fig. 7; SATÔ, 1935, p. 316, Pl. IV, Fig. 17.

This widely distributed tropical species were represented in the collection by only three specimens. They were all taken at Daizyubô and Suô in Formosa being discovered inside of a coral rock laid between the tide-marks.

Of these three specimens mentioned above, the largest one measures about 25 mm in trunk-length and about 13 mm in thickness of body; while the remaining two are much smaller than the first.

The skin of the trunk is grayish white when preserved in alcohol. It appears very smooth and somewhat lustrous to the naked eye. The anal shield is of a horse-shoe-shaped, and is composed of a number of small chitinous bodies of a deep brown colour. A calcareous deposit exists in the centre of the shield. The caudal shield, which is conical in side view and roundish in surface view, bears many grooves radially arranged. When examine this structure under the microscope, it is observed that its surface is covered with numerous small chitinous bodies of deep brown colour. The outer surface of the trunk is covered with numerous small skin-papillae. Each of these skin-papillae is beset with polygonal chitinous plates, and bears a small perforation at its apex.

The introvert, which is light brown in colour, is much narrower and slightly shorter than the trunk. The anterior portion of the introvert carries about 50 complete rings of hooks. Behind these hook-rows, there are distributed numerous spines slightly curved.

The longitudinal muscle layer of the body-wall is entirely continuous. There are two retractor muscles, which arising from the inner surface of the body-wall slightly in front of the caudal shield. With the greater part of their length, they are fused into one band. A spindle-muscle which springs from the anterior extremity of the trunk is fixed to the caudal end of the body. The intestinal convolution consists of about 10 spirals. The segmental organs are two in number, each consisting of a long tube. It is attached to the inner surface of the body-wall by means of mesenteries except for the posterior small portion.

Distribution :

In Japan :   Palau : Yap ; Formosa.

Foreign :   Stiller Ocean ; Koseir ; Philippine ; Red Sea ; Funafuti ; Loyalty Island ; British East Africa ; Malay Peninsula.

81. Aspidosiphon carolinus Satô

Aspidosiphon carolinus Satô, 1935, pp. 318 -320, Pl. IV, Fig. 19; Text-figs. 16-17.
Distribution : Palau.

82. Aspidosiphon truncatus (Keferstein)

Phascolosoma truncatus Keferstein, 1866, p. 50. Taf. VI, Figs. 15-18.
Aspidosiphon truncatus (Keferstein), Selenka et De Man, 1884, pp. 118-119, Taf.
    XIII, Figs. 193-195; Ikeda, 1904, pp. 38-39, Figs. 66-67.
Distribution :
    In Japan: Naha in Riukiu Island ; Koniya in Amami-Ôsima.
    Foreign: Mauritius ; Panama.

83. Aspidosiphon angulatus Ikeda

Aspidosiphon angulatus Ikeda, 1904, pp. 43-45, Figs. 10, 73-77; 1924, p. 37.
Distribution : Kataura (Province of Satuma); Palau.

84. Aspidosiphon mülleri Diesing

Sipunculus scutatus Joh. Müller, 1844, p. 166.
Phascolosoma scutatum Krohn, 1851.
Aspidosiphon mülleri Diesing, 1851, p. 68 & 556; Selenka et De Man, 1884, Taf. I,
    Fig. 11; Ikeda, 1924, p. 38; Fischer, 1914; Sluiter, 1902.
Distribution :
    In Japan: Misaki.
    Foreign: West coasts of Norwey and Sweden ; West coast of
Ireland ; Bay of Biscay ; Mediterranean Sea ; Gulf of Aden ; Azores ;
West coast of Africa ; Indian Ocean.

85. Aspidosiphon spinalis Ikeda

Aspidosiphon spinalis Ikeda, 1904, pp. 47-49, Figs. 12, 81-85; 1924, p. 37.
Distribution : Koniya in Amami-Ôsima and Jaluit Island.

86. Aspidosiphon misakiensis Ikeda

Aspidosiphon misakiensis Ikeda, 1904, pp. 41-43, Figs. 9, 68-72.
Distribution : Misaki.

Genus LITHACROSIPHON SHIPLEY

A solid, conical, stony appendage is present at the anterior end of the trunk. The stony cap born on a pad, and showing traces of a laminated structure. No posterior shield.

87. Lithacrosiphon uniscutatus (IKEDA)

Aspidosiphon uniscutatus IKEDA, 1904, pp. 43-45, Figs. 10, 73-77.

This species was described first by the late Prof. IKEDA in the name of *Aspidosiphon uniscutatus* in 1904, using a single specimen taken from Kataura in the Province of Satuma.

Comparing the IKEDA's description of the *Aspidosiphon uniscutatus* with that of genus *Lithacrosiphon* which has been established by SHIPLEY in 1902, there is found a remarkable identity in general characteristics they have. The writer, therefore, is inclined to removed the *Aspidosiphon uniscutatus* IKEDA into the genus *Lithacrosiphon*.

Distribution: Kataura in the Province of Satuma.

Remarks: This very interesting species has not hitherto been reported from Japanese waters except for the unique description originally given by IKEDA in 1904.

Genus CLOEOSIPHON GRUBE

A roundish cap-like appendage is present at the anterior end of the trunk, and the posterior shield is wanting. The cap-like appendage consists of a spiral series of large papillae of hexahedric in form. The introvert is extruded from the centre of this anterior appendage. The longitudinal muscle layer of the body-wall is continuous. A single retractor muscle is present. Hooks are present upon the anterior portion of the introvert.

88. Cloeosiphon aspergillum (QUATREFAGES)
(Pl. XXI, Figs. 24-25)

Loxosiphon aspergillum QUATREFAGES, 1865, Histoire naturelle des Anneles, II, p. 605, Taf. 20, Fig. 20.

Echinosiphon aspergillum (QUATREFAGES), SLUITER, 1883, pp. 1-14, Pl. I, Figs. 1-14.

Cloeosiphon aspergillum (QUATREFAGES), GRUBE, 1867, Jahresber. der Schles. Gesellsch. für vaterl. Cultur, pp. 48-49; SELENKA & DE MAN, 1883-1884, pp. 126-127, Taf. II, Figs. 23-24, Taf. XIV, Figs. 214-216; FISCHER, 1895, pp. 18-19; 1892, pp. 85-86; 1922, pp. 31-33, Taf. 4, Figs. 40-42; 1926, p. 109; SHIPLEY, 1898, pp. 471-472; 1899, p. 56; 1899, p. 154; 1902, p. 132; 1903, p. 174;

SLUITER, 1902, p. 40; AUGENER, 1903, pp. 297-371; Fig. 16; LANCHESTER, 1905, p. 33 and p. 39; SATÔ, 1935, pp. 321-324, Pl. IV, Fig. 20.

Cloeosiphon mollis SELENKA & DE MAN, 1883-1884, p. 128.

Cloeosiphon javanicum SLUITER, 1890, p. 116.

Cloeosiphon japonicum IKEDA, 1904, pp. 49-53, Figs. 13, 86-89.

Cloeosiphon carolinus IKEDA, 1924, pp. 34-37, Pl. I, Figs. 7-11.

Many specimens of this species were obtained from Daizyubô and Suô in Formosa. They lived in dead coral into which they had bored.

The trunk measures 30-70 mm in length and about 3 mm in diameter. In fresh state, the skin of the animal is coloured light pink; but it becomes gray when preserved in alcohol. In fully expanded specimens, the body-wall is extremely thin being somewhat translucent, but in the contracted specimens it is thick and is yellowish-brown in colour.

The body-surface appears nearly smooth to the naked eye, but with an aid of microscope one can recognize minute skin-papillae covering the whole body. At the anterior end of the introvert, there are about 20 rings of hooks. Each of these hooks measures 0.08-0.09 mm in height. The anal shield is spherical in form, consisting of many large papillae. They are mostly hexagonal in form and are spirally arranged. The external facet of each papilla is covered with calcareous substance.

The longitudinal muscle layer of the body-wall is continuous. A single retractor muscle is present, and its posterior end is divided into two roots with which it attaches to the inner surface of the body-wall. The intestinal convolution consists of about 10 spirals. Spindle-muscle is fixed to the body-wall at its both ends. Only one fixing-muscle is attached to the beginning of rectum. Segmental organs are two in number, each of which being connected to the body-wall with its whole length by means of a mesentery.

Distribution:

In Japan: Amami-Ôsima; Riukiu Island; Formosa; Palau; Yap; Jaluit.

Foreign: Philippine: Caminguin; Zamboango; Luzon; Mauritius; Ibo; Viti-Island; Java; Samoa; Ceylon; Loyalty Island; Maldive Island; Laccadive Island; Christmas Island; Funafuti; Damar Island; Kwandang Bay; Siau Island; Maures; Wain-gapu; Sanguisiapo; Ambon; Kur; Kajoa Island; Obi-major; Lauan Pandan; Haingsisi; Amboina; Penang; Zanzibar.

Remarks: This species is one of the commonest sipunculids being met with in the tropical sea. In 1904 and 1924, IKEDA described two new species of *Cloeosiphon* viz. *Cloeosiphon japonicum* and *Cloeosiphon*

carolinus. But they seem to be synonymous with the present species as already mentioned by the writer in 1935 (pp. 321–324).

C. PRIAPULOIDEA

Genus PRIAPULUS LAMARCK

Introvert club-shaped with 25 longitudinal rows of small spines. The inner surface of the pharynx is furnished with numerous sharp teeth. They are disposed in many sets of pentagons. No tentacles are present. The longitudinal muscle layer of the body-wall is divided into separate bundles. There exist two sets (long and short) of retractor muscles. The alimentary canal is represented by a short straight tube. One or two caudal appendages are present, each of which being composed of numerous narrow blind sacs.

89. Priapulus caudatus LAMARCK

Priapulus caudatus LAMARCK, 1816, Hist. nat. des Anim. sans vert., III, p. 77; SCHWEIGER,
    1820, Handb. der Naturgech. der skelettel. Thiere, p. 553–554; BLAINVILLE,
    Dictionn. des Sc. nat. LVII, p. 554; FLEMING, 1828, A History of British
    Anim. p. 492; FORBES, 1841, A Hist. of Brit. Starf., p. 256; DUEBEN, 1844,
    Oefvers. af K. V. Akad, Foehandl., p. 115; FREY & LEUCKART, 1847, Bei-
    träge zur Kenntniss wirbell. Thiere, p. 40–45; DIESING, 1851, Syst. Helm.,
    II, p. 71 & 556; SARS, 1851, Nyt. Mag. f. Naturv., VI, p. 197; MAITLAND,
    1851, Faun. Belgii Septent., I, p. 97; PHILLIPS, 1853, Report of Brit. Assoc.
    23rd meeting at Hull, p. 70–71; SCHMIDT, 1854, p. 4; GOSSE, 1855, A Manual
    of mar. Zool., I, p. 73; DANIELSSEN, 1861, Nyt. Mag. f. Naturv., XI, p. 58;
    EHLERS, 1862, p. 209; KEFERSTEIN, 1865, p. 440; QUATREFAGES, Hist. nat.
    des Ann., II, p. 601; BAIRD, 1868, pp. 104–106; WILLEMOES-SUHM, Zeits.
    Wiss. Zool. XXI, pp. 386–387; THÉEL, 1875, pp. 20–22; 1906, pp. 15–18;
    HORST, 1881, p. 38; FISCHER, 1895, p. 22; 1896, pp. 6–7; 1921, p. 424; 1922,
    pp. 241–242; 1928, pp. 474–476, Fig. 1; SLUITER, 1912, pp. 22–23; SKORIKOW,
    1902, pp. 274–278; MICHAELSEN, 1889; SOUTHERN, 1913, pp. 1–46; CUÉNOT,
    1922, p. 25; WESENBERG-LUND, 1932, pp. 4–5, Fig. 1; 1934, p. 5; 1937, pp
    2–4, Fig. 1; 1937, pp. 4–6, Fig. 1; OKUDA, 1934, pp. 115–116. Figs. 1–3.
Priapus humanus LINNE, 1758, p. 656.
Holothuria priapus LINNE, 1767, p. 1091.
Priapula caudata GUERIN MENEVILLE, 1829, p. 2.
Priapulus hibernicus M'COY, 1845, p. 272.
Lacazia hibernica QUATREFAGES, 1865, p. 604.
Priapulus glandifer EHLERS, 1862, p. 209.
Priapulus brevicaudatus EHLERS, 1862, p. 209.
Priapulus tuberculato spinosus BAIRD, 1868, p. 106.
Priapulus multidentatus MÖBIUS, 1871.
Priapulus caudatus var. *antarcticus* MICHAELSEN, 1899, p. 18.

Distribution:

In Japan: Akkesi Bay in Hokkaidô.

Foreign: This species is bipolar. In the northern hemisphere it is circumpolar and has its main distribution in the arctic, boreo-arctic and boreal zone of the Atlantic.

Remarks: Only a single specimen has been taken from Hokkaidô by OKUDA in 1934. No record on the occurrence of .this species from Japanese waters is present excepting the OKUDA's report mentioned above.

90. Priapulus bicaudatus DANIELSSEN

Priapulus bicaudatus DANIELSSEN, 1868, Forh. ved. de Skandinav. Naturforskeres tiende Möde, Christiania, p. 542; THÉEL, 1875, p. 23; 1906, pp. 18-19, Pl. I, Figs. 3-6, Pl. II, Figs. 9-10; HORST, 1881, pp. 13-38, Pls. II-III; SKORIKOW, 1901, pp. 274-278; FISCHER, 1914; 1921; 1922, p. 242; 1928, pp. 476-478; WESENBERG-LUND, 1932, p. 5; 1934, pp. 5-6; 1937, pp. 6-7; 1937, pp. 4-5; SATÔ, 1934, pp. 23-28, Pl. I, Fig. 11, Text-figs. 26 31; 1937, p. 168; STIASNY, 1930, p. 221.

Priapulus typica KOREN et DANIELSSEN, 1875.

Priapulus typicus KOREN et DANIELSSEN, 1881 & 1887.

Distribution:

In Japan: Off Kinkazan (Miyagi Prefecture); Off Tosa (Sikoku); Onagawa Bay.

Foreign: Finnmarken; Spitzbergen; Greenland; Norway; Ross Island; Wiide Bay; König-Karls-Land; Barents; Iceland.

Remarks: This species is widely distributed in the North Pacific Sea of Japan, being obtained at many localities distributed in the area stretched from N. Lat. $38°52'47''$ in the north to N. Lat. $32°40'50''$ in the south.

It is very interesting to note that some of the specimens were collected from the rather warm-water at a spot located along N. Lat. $32°40'50''$.

WESENBERG-LUND (1937, p. 6) says on the habitat of this species as follows: — " *Pr. bicaudatus* is a more typical cold-water form than *Pr. caudatus;* corresponding with this its distribution is restricted to the northern parts of the Atlantic. The southernmost finding place hitherto known is off the coast of North Scotland." According to THÉEL (1906) and BALTZER (1931), we know that the southern limit of distribution of the present species is N. Lat. $62°44'$. But from Japanese waters it was obtained at the locality situated along N. Lat. $32°40'50''$ as already mentioned above.

Some of the specimens which were secured from a depth of 104 meters off Sioya-zaki are very large, measuring about 75 mm in' length

and 11–15 mm in width; while the specimens which were taken from the shallow waters of Onagawa Bay are rather small in size measuring only about 35 mm in length even in the largest one. In the smaller specimens, mentioned above, the body-wall is very thin, being almost translucent and the internal organs are developed incompletely. And thus the said specimens, seem to represent the young stage of this species.

III. GENERAL ACCOUNTS ON THE GEOGRAPHICAL DISTRIBU-
TION OF ECHIUROIDEA, SIPUNCULOIDEA AND
PRIAPULOIDEA IN JAPAN

A. ECHIUROIDEA

1) Horizontal distribution

Of Echiuroidea, *Urechis unicinctus* has the widest distribution in Japanese water. It is obtainable abundantly everywhere along the Pacific coast of Japan: from Hokkaidô in the north to Kyûsyû in the south. But there is no record from the coast of "Japan Sea" running along the main lands of Japan. The species, also occurrs in Korea and Dairen.

Among the members of the Echiuroidea found in Japan, both *Echiurus echiurus* and *Arhynchite arhynchite* are the representatives from the cold water. On the contrary, *Thalassema inansense, Ochetostoma erythrogrammon, Listriolobus riukiuensis, Bonellia miyajimai* and *Bonellia fuliginosa* are tropical form, being found in the seas of southern Japan.

While the remaining species of the same group: *Thalassema sabinum, Thalassema owstoni, Thalassema mucosum, Thalassema elegans, Thalassema gogoshimense, Ikeda taenioides, Protobonellia mitsukurii, Protobonellia misakiensis, Acanthohamingia shiplei,* and *Acanthohamingia ijimai* are secured from the seas of Honsyû, Japan, where the climate is mild.

2) Bathymetrical distribution

The majority of the members of Echiuroidea live in shallow water, but there are found several species living in the depth of 180–150 fathoms such as *Acanthohamingia ijimai, Acanthohamingia shiplei, Protobonellia mitsukurii* and *Thalassema owstoni.*

B. SIPUNCULOIDEA

1) Horizontal distribution

The Sipunculoidea contains more number of species than the other two groups of Echiuroidea and Priapuloidea. Sixty-nine species of the

Sipunculoidea have been reported from Japan till the present time.

Of the said sixty-nine species, nineteen were found in the Caroline Islands, nineteen in Formosa and fourteen in Riukiu Islands. These three localities, mentioned above, are placed in the regions of tropical or subtropical.

In Korea, eleven species are found ; of which a single species is proper being found there alone, whilst the remaining ten have a wider distribution.

From Kyûsyû, six species have been recorded, of which *Lithacrosiphon uniscutatus* represents an interesting Sipunculid. In Sikoku, there are found only a single species *Phascolosoma appendiculatum* which is one of the deep-sea forms.

Of the members of Sipunculoidea found in the Japanese waters, the greater number of them are obtained in Honsyû. They are thirty-two in all, complying with nearly the half number of Sipunculid-species found in Japan. This may possibly due to the fact that the region is often visited by collectors, and thus the fauna is probably better known than that of any other area in Japan.

From Hokkaidô, eight species have been recorded ; of which *Physcosoma yezoense*, is found nowhere else, and the remaining seven have a wider distribution. Of these seven species, *Physcosoma japonicum* is found along the coast of Japan extending from Hokkaidô in the north to Formosa in the south.

Physcosoma kurilense is an unique species found at the Shumshir Island which is thought to be the northern limit of the distribution of Sipunculoidea in Japan.

2) *Bathymetrical distribution*

Of the members of Sipunculoidea found in Japan, genus *Siphonosoma*, genus *Physcosoma*, genus *Aspidosiphon*, genus *Cloeosiphon* and genus *Lithacrosiphon* are of littoral type in general. On the other hand, majority of species belonging to the both genera of *Phascolosoma* and *Phascolion*, are represented as of abyssal type as shown in the Table XV. *Phascolosoma okinoseanum*, *Phascolion rectus* and *Phascolion artificiosus*, for example, were secured from a depth of 400 fathoms.

c. PRIAPULOIDEA

Only two species of *Priapulus caudatus* and *Priapulus bicaudatus* have been recorded of Priapuloidea from Japan. They were all found

in cold-water excepting for a single specimen of *Priapulus bicaudatus* which was obtained at a locality situated along N. Lat. 32° 45′ 50″

TABLE XIV

The table showing the Distribution of the Echiuroids occurring in Japan

	Bathymetrical distribution	Horizontal distribution								
		Caroline Islands	Formosa	Riukiu Islands and Amami-Osima	Korea	Kyusyû	Sikoku	Honsyû	Hokkaidô	Okhotsk Sea
Urechis unicinctus	Littoral — several fathoms				O	O	O	O	O	
Echiurus echiurus										O
Arhynchite arhynchite								O		
Thalassema sabinum	Littoral				O			O		
T. owstoni	Littoral — 180 fathoms							O		
T. fuscum										
T. inansense	Littoral			O						
T. mucosum	Littoral							O		
T. elegans	Littoral							O		
T. gogoshimense	Littoral						O	O		
Ikeda taenioides	Littoral — several fathoms					O		O		
Ochetostoma erythrogrammon	Littoral	O	O	O	O					
Listriolobus riukiuensis	Littoral			O						
Bonellia fuliginosa	Littoral			O		O		O		
B. miyajimai	Littoral			O						
Protobonellia mitsukurii	300 fathoms							O		
Parabonellia misakiensis	Littoral							O		
Acanthohamingia shiplei	400 fathoms							O		
A. ijimai	500 fathoms							O		

TABLE XV

The table showing the Distribution of the Sipunculoids occurring in Japan

	Bathymetrical distribution	Horizontal distribution								
		Caroline Islands	Formosa	Riukiu Islands and Amami-Ōsima	Korea	Kyûsyû	Sikoku	Honsyû	Hokkaidô	Shumshir Island
Sipunculus nudus	Littoral – – 516 meters	O	O		O	O		O		
S. indicus	Littoral	O	O							
S. robustus	,,	O								
Siphonosoma cumanense	,,	O	O	O	O	O		O		
S. koreae	,,					O				
S. edule	,,			O	O	O				
S. mourense	,,							O	O	
S. amamiense	,,			O		O				
S. formosa	,,		O							
S. Hatai	,,	O								
S. takatsukii	,,	O								
S. pescadorense	,,		O							
Physcosoma scolops	,,	O	O	O	O	O		O	O	
P. japonicum	,,		O			O		O	O	
P. granulatum	,,	O				O				
P. yezoense	,,								O	
P. glaucum	,,							O		
P. kurilense	,,									O
P. nigrescens	,,	O	O							
P. pacificum	,,	O	O	O						
P. formosense	,,		O							

	Bathymetrical distribution	Horizontal distribution								
		Caroline Islands	Formosa	Riukiu Islands and Amami-Ōsima	Korea	Kyūsyū	Sikoku	Honsyū	Hokkaidô	Shumshir Island
Physcosoma varians	Littoral		O							
P. antillarum	,,			O						
P. pelma	,,	O								
P. albolineatum	,,	O	O	O	O					
P. nahaense	,,			O						
P. onomichianum	,,		O			O		O		
Phascolosoma vulgare	Littoral – 170 meters		O			O		O		
P. misakianum	Littoral							O		
P. owstoni	180 fathoms							O		
P. okinoseanum	400 fathoms							O		
P. appendiculatum	288–527 meters						O			
P. glossipapillosum	249 meters							O		
P. japonicum	Littoral							O		
P. signum	658 meters							O		
P. margaritaceum	172 meters							O		
P. soyo	110–552 meters							O		
P. noto	424 meters							O		
P. pyriformis	Littoral		O	O						
P. nigrum	Littoral					O		O		
P. hyugense	472 meters					O				
P. hozawai	Littoral							O		
P. zenibakense	Littoral — several meters							O	O	
P. onagawa	Several meters							O		
P. catharinae	Littoral — several meters				O			O		

	Bathymetrical distribution	Horizontal distribution								
		Caroline Islands	Formosa	Riukiu Islands and Amami-Ôsima	Korea	Kyûsyû	Sikoku	Honsyû	Hokkaidô	Shumshir Island
Dendrostoma ellipticum	51 meters							O		
D. tropicum	Littoral	O								
D. minor	,,							O		
D. signifer	,,			O						
D. blandum	,,							O	O	
D. hexadactylum	,,							O	O	
Phascolion ikedai	30 fathoms							O		
P. dentalicola	23 meters							O		
P. rectus	400 fathoms							O		
P. artificiosus	400 fathoms							O		
P. lucifugax									O	
Aspidosiphon grandis	Littoral		O							
A. truncatus	,,			O						
A. steenstrupii	,,	O	O	O	O					
A. angulatus	,,	O		O						
A. makoensis	,,		O							
A. formosanus	,,		O							
A. mülleri	30 fathoms							O		
A. spinalis	Littoral	O		O						
A. misakiensis	,,							O		
A. elegans	,,	O								
A. carolinus	,,	O								
Lithacrosiphon uniscutatus	,,					O				
Cloeosiphon aspergillum	,,	O	O	O						

TABLE   XVI

The table showing the Distribution of the Priapuloids
occurring in Japan

	Bathymetrical distribution	Horizontal distribution		
		Sikoku	Honsyû	Hokkaidô
Priapulus caudatus	Littoral			○
Priapulus bicaudatus	10–680 meters	○	○	

Of these two species, *Priapulus caudatus* is very rare in Japan, being collected only a single specimen from Hokkaidô.   On the contrary, another species, *Priapulus bicaudatus* is rather common.   It is obtainable numerously along the Pacific coast of Northeast Honsyû, Japan.

With regard to the bathymetrical distribution, there are found a remarkable difference between these two species :   *Priapulus caudatus* was discovered, in our -country, at the shore of Akkesi (in Hokkaidô); while, *Priapulus bicaudatus* was collected at a depth of 10--680 meters.

IV. SYNOPSIS OF ECHIUROIDEA, SIPUNCULOIDEA AND
PRIAPULOIDEA FOUND IN JAPAN

A. KEY TO THE GENERA AND SPECIES OF
ECHIUROIDEA FOUND IN JAPAN

1. Proboscis present. 3, 4
2. Proboscis absent. ....Genus *Arhynchite* SATÔ
3. Sexes of similar appearance.   More than a pair of gonoducts
   are present. 5, 6
4. Sexual dimorphism remarkably pronounced.   Only a single
   gonoduct is present. 14, 15
5. Both ventral and anal setae are present. 7, 8
6. Ventral setae are present, but devoid of anal setae. 9, 10
7. Anal setae arranged in a single circle around the anus. ....
   ....Genus *Urechis* SEITZ
8. Anal setae arranged in double circles around the anus.......
   ....Genus *Echiurus* GUÉRIN
9. Gonoducts arranged in pairs.   Longitudinal muscle layer of
   body-wall lies inside of the circular muscle layer........11, 12, 13
10. Gonoducts arranged not in pairs, and are numerous in number

(200–400). Longitudinal muscle layer of body-wall lies outside of the circular muscle layer. Proboscis remarkably long. . . . .
. . . . .Genus *Ikeda* WHARTON

┌11. Longitudinal muscle layer of body-wall is of uniform thickness throughout. .Genus *Thalassema* LAMARCK

├12. Longitudinal muscle layer of body-wall interrupted by intervals, so that it appears to be separated, but in reality they are connected by a very thin layer of longitudinal muscle fibres . lying between the bundles. . . . .
. . . . Genus *Ochetostoma* LEUCKART & RÜPPELL

└13. Longitudinal muscle layer is thickened into bundles at intervals, and is not interrupted between the bundles, but simply becomes thinner, forming undulations. . . . .Genus *Listriolobus* SPENGEL

┌14. Proboscis bifurcated at apex. 16, 17

└15. Proboscis not bifurcated at apex. .18, 19

┌16. Ventral setae are present. . . . . . .Genus *Bonellia* ROLANDO

└17. Ventral setae are absent. . . . . .Genus *Parabonellia* ONODA

┌18. A pair of ventral setae are present. . . . .
. . . . .Genus *Protobonellia* IKEDA

└19. Ventral setae are numerous and very minute. . . . .
. . . . .Genus *Acanthohamingia* IKEDA

Genus ARHYNCHITE SATÔ

Genus *Arhynchite* contains only a single species *Arhynchite arhynchite* (IKEDA), the short diagnosis of which is as follows: Without proboscis. Two ventral setae exists close to and behind the mouth. No anal setae. Dermal musculature forms a continuous sheet. A pair of gonoducts, each of which is provided with a leaf-like appendage.

Genus URECHIS SEITZ

Genus *Urechis* is represented in our country, by a single species, *Urechis unicinctus* (von DRASCHE). The short diagnosis of the species is as follows: Proboscis short, scoop-shaped. Two ventral setae exist close to the mouth. Anal setae are counted 10–13 in number. Gonoducts are in two pairs, each provided with two long spiral appendages.

Genus ECHIURUS GUERIN

Of the genus *Echiurus* only a single species, *Echiurus echiurus* (PALLS)

is found in our country. The following is the short diagnosis of it:
Proboscis shorter than the body. Gonoducts are in two pairs. Of the
double circlets of the anal setae, the outer circlets consists of 11 setae
and the inner 8 of these.

Genus THALASSEMA LAMARCK

1. Gonoducts are in one pair. 5, 6
2. Gonoducts are in 2 pairs. . . . . . .*Thalassema sabinum* LANCHESTER
3. ,Gonoducts are in 3 pairs. 7, 8
4. Gonoducts are in more than 3 pairs. 9, 10
5. Ventral setae with interbasal muscle. . . . .
. . . .*Thalassema owstoni* IKEDA
6. Ventral setae without interbasal muscle. . . . . ,
. . . .*Thalassema fuscum* IKEDA
7. The anteriormost pair of gonoducts lie in front of the ventral
setae. . . . .*Thalassema inansense* IKEDA
8. All gonoducts lie behind the ventral setae. . . . .
. . . .*Thalassema mucosum* IKEDA
9. Gonoducts are grouped commonly into 7 pairs, each group
consisting of 0-3 large organs. . .*Thalassema elegans* IKEDA
10. Gonoducts, in the female, are in 3 pairs, while in the male
they are found 6 or 8 groups arranged pairwise, each group
consisting of 1-4 organs. . . . .*Thalassema gogoshimense* IKEDA

Genus OCHETOSTOMA LEUCKART & RÜPPELL

Genus *Ochetostoma* contains a single species *Ochetostoma erythrogram-
mon* (LEUCKART & RÜPPELL). The following is the diagnosis of the
species: Proboscis shorter than the body. Dermal musculature has 14-
18 longitudinal striations. Gonoducts are 3 pairs, each provided with 2
short spiral appendages. Tropical form.

Genus LISTRIOLOBUS SPENGEL

Genus *Listriolobus* is represented by a single species *Listriolobus riu-
kiuensis* SATÔ in our country. The short diagnosis of the species is as
follows: Proboscis very long, measuring about 130 mm in length when
fully stretched. Three pairs of the gonoducts are present. The anterior
pair are exist in front of the ventral setae. No interbasal muscle is
present.

Genus IKEDA WHARTON

In the genus *Ikeda* only a single species *Ikeda taenioides* (IKEDA) is contained. Short diagnosis of the species is as follows: Body enormously large, measuring up to 400 mm in length and 30 mm in thickness. Proboscis, when fully extended, is as long as 1000–1500 mm. The skin shows deep reddish-brown colour, and there are seen five narrow longitudinal striations on the body-surface. The ventral setae are small.

Genus BONELLIA ROLANDO

┌─1. Ventral setae are set in one pair. . .*Bonellia fuliginosa* ROLANDO
└─2. Ventral setae are numerous in number. . . . .
. . . .*Bonellia miyajimai* IKEDA

Genus PARABONELLIA ONODA

Genus *Parabonellia* is represented by a single species *Parabonellia misakiensis* (IKEDA), and the short diagnosis of it is as follows: In the female, the body is swollen and the long proboscis is bifurcated at apex. The male is small and nematode-like, without mouth and anus, measuring 3.5 mm in length.

Genus PROTOBONELLIA IKEDA

Genus *Protobonellia* contains a single species, *Protobonellia mitsukurii* IKEDA. The following is a short diagnosis of this species: Proboscis long, tube-like, and not bifurcated at apex. Body elongated egg-shaped. Skin thin and translucent. Deep-sea form.

Genus ACANTHOHAMINGIA IKEDA

┌─1. Each of the ventral setae is small in size (0.1 mm in height) with a curved and pointed apex. Deep-sea form. . . . .
│ . . . .*Acanthohamingia shiplei* IKEDA
└─2. Ventral setae are less curved and larger than those found in *Acanthohamingia shiplei*. . . . .*Acanthohamingia ijimai* (IKEDA)

B. KEY TO THE GENERA AND SPECIES OF
SIPUNCULOIDEA FOUND IN JAPAN

1. Horny or calcareous shield is absent at both ends of the trunk. 3, 4

2. Horny or calcareous shield is present at both ends (sometimes only at the anterior end) of the trunk. 13, 14, 15

3. Longitudinal muscle layer of the body-wall is divided into separate bundles. .. ..,.............................5, 6

4. Longitudinal muscle layer of the body-wall is continuous. ..9, 10

5. Body large and long. The surface of the trunk devoid of the prominent papillae being smooth to the nacked eye. Longitudinal muscle bands are not frequently anastomosed. 7, 8

6. Body small and short. The surface of the trunk is covered by well developed papillae which are easily recognizable to the nacked eye. Longitudinal muscle bands are frequently anastomosed. .... Genus *Physcosoma* SELENKA

7. The surface of the trunk is divided into numerous small rectangular areas which are formed by the intersection of the longitudinal and circular muscle-bands. Tentacles leaf-like. Introvert with tall, triangular scale-like papillae posteriorly directed. ....Genus *Sipunculus* LINNAEUS

8. Body-surface shows no rectangular areas due to the body muscles. Tentacles filamentous. No prominent scale-like papillae on the introvert..........Genus *Siphonosoma* SPENGEL

9. Two segmental organs and a spindle-muscle present.......11, 12

10. Only one segmental organ; spindle muscle wanting. ....Genus *Phascolion* THÉEL

11. Tentacles filamentous. ....Genus *Phascolosoma* LEUCKART

12. Tentacles dendritic. ....Genus *Dendrostoma* GRUBE

13. A horny or calcareous shield-like appendage is present at both ends of the trunk. The introvert arises from the ventral side of the anal shield..............Genus *Aspidosiphon* GRUBE

14. A round cap-like appendage is present at the anterior end of the trunk, and the posterior shield is wanting. The introvert is extruded from the centre of this anterior appendage....... ....Genus *Cloeosiphon* GRUBE

15. A tall, cone-shaped appendage which is very hard to touch like stone, is present at the anterior end of the trunk. No

posterior shield. The introvert is extruded from an orifice
opened ventrally just behind the appendage..................
...........................Genus *Lithacrosiphon* SHIPLEY

Genus PHYSCOSOMA SELENKA

┌─ 1. Hooks are absent on the introvert. 3, 4
└─ 2. Hooks are present on the introvert. 5, 6

┌─ 3. Four retractor muscles..7, 8
└─ 4. Two retractor muscles...*Physcosoma onomichianum* (IKEDA)

┌─ 5. Four retractor muscles. 9, 10
└─ 6. Two retractor muscles. ...*Physcosoma nahaense* (IKEDA)

┌─ 7. Skin-papillae formed of many plates concentrically arranged,
│   which decrease in size peripherally. ....
│   ....*Physcosoma antillarum* (GRUBE & OERSTED)
└─ 8. Skin-papillae formed of very few plates concentrically arranged.
       ....*Physcosoma pelma* (SELENKA & DE MAN)

┌─ 9. Segmental organs are very long, reaching the posterior end of
│   the trunk. They are attached to the body-wall through their
│   whole length. ....*Physcosoma pacificum* (KEFERSTEIN)
└─10. Segmental organs are short, not being attached to the body-
       wall through their whole length. 11, 12

┌─11. Hooks bent, forming a right angle. 13, 14
└─12. Hooks bent, forming an angle wider than right angle.....15, 16

┌─13. Skin thick and dirty grayish-brown in colour. The surface of
│   the skin is very rough as in the case of *Physcosoma nigrescens*
│   Introvert as long or longer than the trunk.................
│   ....*Physcosoma varians* (KEFERSTEIN)
└─14. Skin thin, somewhat translucent. In fresh state, the skin shows
       beautiful yellowish vermilion colour, but it decades into grayish
       white when preserved in alcohol. Introvert as long as half of
       the trunk-length. ......*Physcosoma albolineatum* (BAIRD)

┌─15. Hooks are very few in number, being scattered at the anterior
│   end of the introvert.....*Physcosoma formosense* SATÔ
└─16. Hooks numerous and arranged in many rings. 17, 18

┌─17. Numerous scattered hooks are present behind the hook-rows.
│   ....*Physcosoma nigrescens* (KEFERSTEIN)
└─18. Scattered hooks seen in the case of *Physcosoma nigrescens* are
       not found behind the hook-rows. 19, 20

-19. Hooks strongly bending, with sharply pointed apex. 21, 22

-20. Hooks not strongly bending, without sharply pointed apex. ..
.....................*Physcosoma glaucum* SATÔ

-21. Ventral retractor muscles attached to the posterior end of the
trunk. Hooks very small, measuring 0.045 mm in height.....
.....................*Physcosoma yezoense* IKEDA

-22. Ventral retractor muscles not attached to the posterior end of
the trunk. Hooks large, measuring about 0.07 mm in height.
....23, 24

-23. Segmental organ divided into two (anterior and posterior)
lobes. ....*Physcosoma kurilense* SATÔ

-24. Segmental organ not divided into two lobes. 25, 26

-25. Skin-papillae on the introvert-basis very tall. Transparent
streak of the hook divided into two branches near its base...
.....................*Physcosoma scolops* (SELENKA & DE MAN)

-26. Skin-papillae on the introvert-basis not prominent as in the
case of *Physcosoma scolops*. Transparent streak of the hook
not divided into two branches. 27, 28

-27. Skin-papillae found in the middle of the trunk is covered with
large polygonal chitinous plates. ....
.....................*Physcosoma japonicum* (GRUBE)

-28. Skin-papillae found in the middle of the trunk is covered with
small polygonal chitinous plates. ....
.....................*Physcosoma granulatum* (LEUCKART)

Genus SIPUNCULUS LINNAEUS

- 1. Longitudinal muscle layer of the body-wall is divided into 24–
32 separate bundles......................................3, 4

- 2. Longitudinal muscle layer of the body-wall is divided into 38–
41 separate bundles. Body long. Tropical form. ....
.....................*Sipunculus indicus* PETERS

- 3. A pair of tuft-like organs are present upon the rectum. Cosmo-
politan species. ....*Sipunculus nudus* LINNAEUS

- 4. No tuft-like organs are present upon the rectum. Tropical
form. ....,......*Sipunculus robustus* (KEFERSTEIN)

Genus SIPHONOSOMA SPENGEL

┌ 1. Spines are present on the introvert. 3, 4
└ 2. Spines are absent on the introvert. 5, 6
┌ 3. Skin is thick and is entirely opaque. . . . . ‹
│   . . . .*Siphonosoma takatsukii* SATÔ
└ 4. Skin is very thin, being somewhat translucent. . . . .
    . . . .*Siphonosoma pescadolense* SATÔ
┌ 5. Each pair of the retractor muscles ariese from different levels.
│   Crescent-shaped dissepiments absent. 7, 8
└ 6. Each pair of the retractor muscles arise from nearly the same
    level. Crescent-shaped dissepiments present. 9, 10
┌ 7. Longitudinal muscle layer is divided into 22 bands. . . . .
│   . . . .*Siphonosoma mourense* SATÔ
└ 8. Longitudinal muscle layer is divided into 15–16 bands. . . . . . .
    . . . .*Siphonosoma amamiense* (IKEDA)
┌ 9. Longitudinal muscle layer is divided into 18 bands. . . . .
│   . . . .*Siphonosoma formosa* SATÔ
└10. Longitudinal muscle layer is divided into 20–24 bands. 11, 12
┌11. Introvert short, being 1/10–1/8 as long as the trunk. Longi-
│   tudinal muscle layer is divided into 20–21 bands. . . . .
│   . . . .*Siphonosoma edule* (SLUITER)
└12. Introvert long being about 1/4–1/3 as long as the trunk. . .13, 14
┌13. Body is very short, being about only 70 mm. Longitudinal
│   muscle layer is divided into 20–21 bands. . . . .
│   . . . .*Siphonosoma hataii* SATÔ
└14. Body is very long, generally being 200–400 mm. 15, 16
┌15. Introvert, introvert-basis and body-end are of beautiful yellow
│   colour. The skin-papillae on the introvert-basis is very pro-
│   minent. . . . .*Siphonosoma koreae* SATÔ
└16. The beautiful yellow colour as in the case of *Siphonosoma
    koreae* absent. The skin-papillae on the introvert-basis is not
    prominent. . . . .*Siphonosoma cumanense* (KEFERSTEIN)

Genus PHASCOLION THÉEL

┌1. Spines present on the introvert. .3, 4
└2. Spines absent on the introvert. 5, 6
┌3. A single retractor muscle with two roots. . .*Phascolion ikedai* SATÔ
└4. Two retractor muscles. 7, 8

⌐5. Skin-papillae are small and thus the middle region of the trunk
     seems almost smooth. Body straight...*Phascolion rectus* IKEDA
└6. The middle region of the trunk covered with large papillae.
     Body coiled into a spiral............*Phascolion artificiosus* IKEDA
⌐7. The top of each spine on the introvert is rounded..........
     ....*Phascolion lucifugax* SELENKA & DE MAN
└8. The top of each spine on the introvert rather sharply pointed.
     ....*Phascolion dentalicola* SATÔ

Genus PHASCOLOSOMA LEUCKART

⌐ 1. Four retractor muscles.................................3, 4
└ 2. Two retractor muscles................................22, 23
⌐ 3. Hooks present on the introvert.........................5, 6
└ 4. Hooks absent on the introvert.........................9, 10
⌐ 5. Hooks provided with 4–5 small accessory teeth, are arranged
      in many transverse rows...*Phascolosoma misakianum* IKEDA
└ 6. Hooks dispersed, and devoid of accessory teeth............7, 8
⌐ 7. Skin-papillae on the introvert-basis are cylindrical and very
      tall, measuring 0.13 mm in height. Hooks are small, measuring
      0.065–0.15 mm in height...*Phascolosoma vulgare* (DE BLAINVELLE)
└ 8. Skin-papillae on the introvert-basis are roundish and very small.
      Hooks are tall, measuring 0.13–0.22 mm in height..........
      ....*Phascolosoma owstoni* IKEDA
⌐ 9. Respiratory apparatus present over the surface of the trunk...
      ....*Phascolosoma okinoseanum* IKEDA
└10. No respiratory apparatus on the trunk-surface. 11, 12
⌐11. Posterior end of the trunk with a narrow cord-like appendage
      of about 10 mm long. ....*Phascolosoma appendiculatum* SATÔ
└12. Posterior end of the trunk devoid of a cord-like appendage...
      ....13, 14
⌐13. Skin-papillae on the body-surface are peculiarly shaped in
      tongue-like manner. ......*Phascolosoma glossipapillosum* SATÔ
└14. Skin-papillae on the body-surface are not shaped in tongue-like
      manner. 15, 16
⌐15. Skin-papillae on the body-surface are flattened, and uniform in
      size throughout the whole surface of the trunk. ....
      ....*Phascolosoma japonicum* IKEDA
└16. Skin-papillae on the body-surface are generally tall, but those

found at both ends of the trunk are of two type the large
and the small...17, 18, 19

-17. Peculiar ripple-marks are present on the skin-surface at the
posterior end of the trunk. *Phascolosoma signum* SATÔ

-18. Peculiar reticulation formed by pigmentation is present at the
posterior region of the body. ....
.......................*Phascolosoma margaritaceum* (SARS)

-19. Neither peculiar ripple-marks nor reticulation are present at
the posterior region of the body. 20, 21

-20. Skin-papillae on the introvert are cone-shaped and very tall
.......................*Phascolosoma soyo* SATÔ

-21. Skin-papillae on the introvert are law, and mixed with minute
papillae of pear-shaped. ..*Phascolosoma noto* SATÔ

-22. Anus and segmental organs open on the introvert..........
.......................*Phascolosoma pyriformis* LANCHESTER

-23. Anus and segmental organs not open on the introvert.....24, 25

-24. Introvert remarkably long (2.5 times as long as the trunk)...
.......................*Phascolosoma nigrum* IKEDA

-25. Introvert is equal to or shorter than the trunk..........26, 27

-26. Tentacular crown consists of many tentacles arranged in com-
plex rows. 28, 29

-27. Tentacular crown is formed by a single row of tentacles.....
.......................*Phascolosoma hyugense* SATÔ

-28. Fixing-muscle absent. ....*Phascolosoma hozawai* SATÔ

-29. Fixing-muscle present. 30, 31

-30. Skin-papillae are very small and almost uniform in size through-
out the whole surface of the body. They measure 0.03–0.05
mm in height. ....*Phascolosoma zenibakense* IKEDA

-31. Skin-papillae are tall, and these on the introvert-basis are re-
markably taller than those on the middle region of the trunk
....32, 33

-32. Skin-papillae on the introvert-basis are tall and club-shaped,
measuring about 0.12 mm in height. Three fixing-muscles.
.......................*Phascolosoma onagawa* SATÔ

-33. Skin-papillae on the introvert-basis are cylindrical, measuring
about 0.09 mm in height. Two fixing-muscles..............
.......................*Phascolosoma catharinae* MÜLLER

Genus DENDROSTOMA GRUBE

1. Polian tubules extremely short. 3, 4
2. Polian tubules extremely long. 7, 8
3. Hooks present on the introvert...*Dendrostoma minor* IKEDA
4. Hooks absent on the introvert. 5, 6
5. Skin-papillae are elongated elliptical in surface view. ....
 .... *Dendrostoma ellipticum* SATÔ
6. Skin-papillae are roundish in surface view. ....
 .... *Dendrostoma tropicum* SATÔ
7. Hooks present on the introvert. 9, 10
8. Hooks absent on the introvert. ....
 ....*Dendrostoma signifer* SELENKA & DE MAN
9. Four main tentacular stems.................................
 ....*Dendrostoma blandum* SELENKA & DE MAN
10. Six main tentacular stems...... .*Dendrostoma hexadactylum* SATÔ

Genus ASPIDOSIPHON GRUBE

1. Longitudinal muscle layer of the body-wall separated into
 bundles. 3, 4
2. Longitudinal muscle layer of the body-wall continuous. 12, 13
3. Retractor muscles attached to the caudal shield............
 ....*Aspidosiphon truncatus* (KEFERSTEIN)
4. Retractor muscles inserted in front of the caudal shield. ...5, 6, 7
5. A single retractor muscle with 4 short roots. ....
 ....*Aspidosiphon grandis* SATÔ
6. A single retractor muscle with 2 short roots. ....
 ....*Aspidosiphon steenstrupii* DIESING
7. Two retractor muscles.................................8, 9
8. No skin-papillae are present over the greater part of the trunk.
 ....*Aspidosiphon angulatus* IKEDA
9. Skin-papillae are distributed all over the trunk. 10, 11
10. Anterior half of the retractor muscles are fused into one band
 ....*Aspidosiphon makoensis* SATÔ
11. Anterior half of the retractor muscles are not fused into one
 band. ....*Aspidosiphon formosanus* SATÔ
12. Retractor muscles attached to the caudal shield............
 ....*Aspidosiphon mülleri* DIESING
13. Retractor muscles inserted in front of the caudal shield. ...14, 15

Genus CLOEOSIPHON GRUBE

Genus *Cloeosiphon* contains only one species, *Cloeosiphon aspergillum* (QUATREFAGES). The short diagnosis of the species is as follows. The longitudinal muscle layer of the body-wall is continuous. A single retractor muscle, the posterior portion of which is divided into two roots. The anterior cap-like appendage consists of numerous papillae, arranged spirally. The top of each of the papillae is covered with calcareous substance. 20–25 complete rings of hooks are present at the anterior end of the introvert.

Genus LITHACROSIPHON SHIPLEY

Genus *Lithacrosiphon* contains, in our country, a single species *Lithacrosiphon uniscutatus* (IKEDA). The following is the short diagnosis of the species: The longitudinal muscle layer of body-wall is divided into bundles frequently anastomosed, but these are quite continuous at both ends of the trunk. A single retractor muscle with two roots. The anterior portion of the introvert carries numerous complete ring-rows of hooks.

C. KEY TO THE GENERA AND SPECIES OF
PRIAPULOIDEA FOUND IN JAPAN

From Japanese water, only one genus, *Priapulus* LAMARCK, has been reported of this group.

Genus PRIAPULUS LAMARCK

Introvert club-shaped with 25 longitudinal rows of small spines. The inner surface of the pharynx is furnished with numerous sharp teeth. They are disposed in many sets of pentagons. No tentacles are present. The longitudinal muscle layer of the body-wall is divided into separate bundles. There exist two sets (longer and shorter) of retractor muscles: The longer muscles are 8 in number, and the shorter are 10-14. The alimentary canal is represented by a short straight tube. One or two caudal appendages are present. Each are composed of narrow numerous blind sacs.

1. One tuft of the caudal appendage is present. The teeth set on the outermost pentagon are 5 in number.................
.............................*Priapulus caudatus* LAMARCK
2. Two tufts of the caudal appendages are present. The teeth set on the outermost pentagon are 10 in number. ....
.........................*Priapulus bicaudatus* DANIELSSEN

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EXPLANATION OF THE PLATES

PLATE XIX.

Fig. 1. *Ochetostoma erythrogrammon* (REUCKART et RÜPPELL). A specimen collected by the writer. Natural size.

Fig. 2. *Ochetostoma erythrogrammon* (REUCKART et RÜPPELL). A specimen sent by Mr. I. HARADA. Natural size.

Fig. 3. *Sipunculus nudus* LINNAEUS. Natural size.

Fig. 4. *Sipunculus indicus* PETERS. Natural size.

PLATE XX

Fig. 5. *Siphonosoma cumanense* (KEFERSTEIN). Natural size.

Fig. 6. *Siphonosoma edule* SLUITER. Natural size.

Fig. 7. *Siphonosoma formosa*, n. sp. Natural size.

Fig. 8. *Siphonosoma pescadolense*, n. sp. Natural size.

Fig. 9. *Physcosoma scolops* (SELENKA et DE MAN). Natural size.

Fig. 10. *Physcosoma albolineatum* (BAIRD). Natural size.

Fig. 11. *Physcosoma varians* (KEFERSTEIN). Natural size.

Fig. 12. *Physcosoma japonicum* (GRUBE). Natural size.

Fig. 13. *Physcosoma nigrescens* (KEFERSTEIN). Natural size.

Fig. 14. *Physcosoma onomichianum* (IKEDA). Natural size.

Fig. 15. *Physcosoma formosense*, n. sp. Natural size.

PLATE XXI

Fig. 16. *Phascolosoma pyriformis* LANCHESTER. Natural size.

Fig. 17. *Phascolosoma vulgare* (DE BLAINVILLE). Natural size.

Fig. 18. *Aspidosiphon steenstrupii* (DIESING). A specimen from Daihanratu. Natural size.

Fig. 19. *Aspidosiphon steenstrupii* (DIESING). A specimen from Nekobana. Natural size.

Fig. 20. *Aspidosiphon elegans* (CHAMISSO et EYSENHARDT). Natural size.

Fig. 21. *Aspidosiphon grandis*, n. sp. Natural size.

Fig. 22. *Aspidosiphon makoensis*, n. sp. Natural size.

Fig. 23. *Aspidosiphon formosanus*, n. sp. Natural size.

Fig. 24. *Cloeosiphon aspergillum* (QUATREFAGES). A specimen from Daizyubô. Natural size.

Fig. 25. *Cloeosiphon aspergillum* (QUATREFAGES). A specimen from Suo. Natural size.

PLATE XXII

Fig. 26. *Urechis unicinctus* (von DRASCHE). Natural size.

Fig. 27. *Urechis unicinctus* (von DRASCHE). An animal dried for food. Natural size.

Fig. 28. *Thalassema mucosum* IKEDA. Natural size.

Fig. 29. *Thalassema sabinum* LANCHESTER. Natural size.

Fig. 30. *Ochetostoma erythrogrammon* (LEUCKART & RÜPPELL).
Fig. 31. *Sipunculus nudus* LINNAEUS. Natural size.
Fig. 32. *Siphonosoma cumanense* (KEFERSTEIN). A specimen from Gunzan. Natural size.

PLATE XXIII

Fig. 33. *Siphonosoma cumanese* (KEFERSTEIN). A specimen from Reisui. Natural size.
Fig. 34. *Siphonosoma koreae*, n. sp. Natural size.
Fig. 35. *Phascolosoma vulgare* (DE BLAINVILLE). Natural size.
Fig. 36. *Phascolosoma catharinae* F. MÜLLER. A specimen from Wandô. Natural size.
Fig. 37. *Phascolosoma catharinae* F. MÜLLER. A specimen from Moppo. Natural size.
Fig. 38. *Physcosoma scolops* (SELENKA & DE MAN). A large specimen from Zinsen. Natural size.
Fig. 39. *Physcosoma scolops* (SELENKA & DE MAN). A small specimen from Uturyô-tô. Natural size.
Fig. 40. *Physcosoma granulatum* (LEUCKART). Natural size.
Fig. 41. *Physcosoma japonicum* (GRUBE). Natural size.
Fig. 42. *Physcosoma albolineatum* (BAIRD). Natural size.
Fig. 43. *Physcosoma onomichianum* (IKEDA). Natural size.
Fig. 44. *Aspidosiphon steenstrupii* DIESING. Natural size.
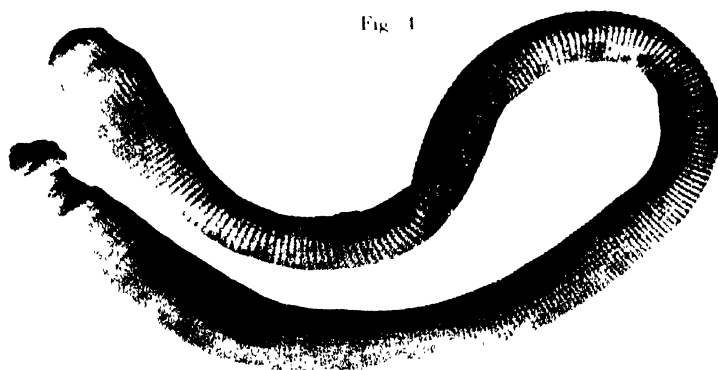
Fig. 1

Fig. 2

Fig. 3

Fig. 4

H. Satô: Echiuroidea, Sipunculoidea and Priapuloidea of Japan.

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

H. SATÒ: Echiuroidea, Sipunculoidea and Priapuloidea of Japan.